UNION OF SOUTH AFRICA
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GEOLOGICAL SURVEY
GEOLOGIESE OPNAME

THE CHROMITE DEPOSITS IN THE RUSTENBURG AREA

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BULLETIN 27

by

G. P. Fourie, M.Sc.

Met 'n opsomming in Afrikaans onder die opskrif:

DIE CHROMIETAFSETTINGS IN DIE GEBIED RUSTENBURG

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THE CHROMITE DEPOSITS IN THE RUSTENBURG AREA

ABSTRACT

Previous geological investigations undertaken in the area with regard to the chromite deposits since 1908 are reviewed. The customary use of the term *chromite* is explained.

The general landscape is flat, and isolated hills of norite and pyroxenite are aligned parallel to the strike of the rocks. The drainage is northwards.

The chromite seams occur from 560 to 3,150 feet below the well-known platiniferous Merensky Reef, in a portion of the Bushveld Igneous Complex, which is comprised of pyroxenite, norite and anorthosite. They form three groups, the upper, middel and lower groups, each of which is separately described. There are at least 25 seams. These range in thickness from a fraction of an inch up to a maximum of about 6 feet; an average figure is from 18 to 40 inches. The dip of the seams is from 4° to 13° in a predominantly northerly to north-easterly direction, and abnormal dips are also encountered. As a general rule the lower seams are associated with the pyroxenites of the Bushveld Igneous Complex, but the upper seams occur in anorthosite and less basic rocks; outcrops are scarce, owing to a cover of black turf soil.

The area is, for the sake of convenience, divided into the following two sectors: (*a*) the Rustenburg-Marikana Sector and (*b*) the Rustenburg-Boshoek Sector. The occurrences of the various groups of chromite seams occurring on different farms in the two sectors are individually described and names are given to the more important ones. Their geological, mineralogical, physical and chemical characteristics are described.

Views of previous observers regarding the origin of the chromite seams are recorded and comments on these views are made. Problems relating to the correlation of the different seams from one locality to the next are discussed. The present correlation is based on (*a*) the type of country-rock, (*b*) the presence of markers, (*c*) thicknesses of individual seams and (*d*) rhythms in the succession in the group.

A chapter is devoted to the physical properties of the seams and their associated minerals.

Methods used for ore-concentration, grading and the marketing of the mineral are discussed. Various industrial types of ore are mentioned. Production figures since 1924 and the present reserves of ore are tabulated, and the production of cheap stainless chrome steel is noted.

The bulletin is accompanied by photographs, geological sections and a map. A bibliography is provided.

I.—INTRODUCTION

A. PREVIOUS WORK

On his sketch-map C. Mauch, who visited the area in about 1865, indicated the occurrence of chromite near the Hex River. The mineral was first mentioned in official reports by G. A. F. Molengraaff in 1898 (^{21}, p. 5).*

---

* Figures in parentheses refer to the bibliography at the end of this publication.

A. L. Hall and W. A. Humphrey (11) in 1908, W. A. Humphrey and H. Kynaston (15) in 1908, P. A. Wagner (30) in 1923, W. Kupferbürger, B. V. Lombaard, B. Wasserstein and C. M. Schwellnus (18) in 1937 and C. F. J. van der Walt (27) in 1941 all contributed valuable information about the chromite deposits of the area.

B. SCOPE OF WORK

The primary object of the present investigation, undertaken during 1955, was to report on the economic geology of Area No. 4, Rustenburg, but simultaneously to bear in mind a future memoir on the chromite deposits of the Transvaal.

Eventually much more data accumulated than was expected, especially in correlating the different seams. Kupferbürger and his fellow-authors (18, p. 9) state: "There is at present not sufficient information which could assist in improving the somewhat unsatisfactory correlation of the different seams." It is hoped that this publication will contribute to the pioneer work of these authors.

This area is of importance as an actual and potential source of chrome, and this publication may serve rather as a guide to mining and prospecting than as an authority on the genesis of the chromite itself.

C. TERMINOLOGY.

The use of the term *chromite* in this bulletin is not strictly correct. In mineralogy the term *chromite* is reserved for spinel that is composed of pure, or nearly pure $FeO.Cr_2O_3$, but here it will be used to designate the gangue-free spinel mineral that in the Bushveld is mainly composed of the oxides Cr_2O_3, FeO, Al_2O_3 and MgO. Petersen (38, p. 231) has suggested the name *chrompicotite* for ores that contain appreciable quantities of Al_2O_3 and MgO in addition to the oxides mentioned, and the Bushveld chromite may thus more accurately be so named. According to Niggli's suggestion for the classification of the spinel group, the mineral in the Bushveld ore should be called *beresovite*. It has been customary, however, to use *chromite* for the Bushveld mineral, and a change at present seems unwise.

The rock or material consisting of chromite and associated gangue in the form of silicates, and at some localities also non-silicates, such as magnetite, etc., has been called *chromitite* (38, p. 224), a name which serves a useful purpose and will be used in that sense in this paper.

The name *chrome ore* has a wider meaning than either chromite or chromitite and is applicable to any material that can be used industrially and for the extraction of the metal.

The name *Main Seam* is used especially in the eastern Transvaal and the Rustenburg area, where it is still being mined extensively. It is located in the upper portion of the lower group of chromitite seams. The ubiquitous *Leader Seam* at most places occurs from 1 to 3 feet higher up. The above two seams constitute the so-called "*Main Horizon*".

The Magazine Seam is the name used for a chromitite seam in the upper portion of the lower group of seams in the Swartkop and Pilanesberg areas of western Transvaal. At Swartkop Mine the *Leader Seam* occurs 15 feet above the Magazine Seam.

At Swartkop Mine the *Roamer Seam* lies 95 feet below the Magazine Seam and, in descending order, consists of three seams 4, 8 and 6 inches thick and spread over a width of 4 to 5 feet. Three similar seams, 4, 9 and 6 inches thick, occur from 80 to 100 feet below the Magazine Seam in the Pilanesberg area on Palmietfontein 208 J.P. Here they are known as the *Garage Seam*. In the Rustenburg area an identical group of thin seams is situated below the Main Seam and for the purpose of correlation and uniformity, they have been designated the "*Roamer Horizon*".

D. ACKNOWLEDGEMENTS.

The author owes the sincerest thanks to Messrs. Beath (Manager of Bleskop Platinum Mine), Lawson (Manager of Kroondal Chrome Mine), Bauristhene (Manager of Bultfontein Chrome Mine), Van Schalkwyk (Manager of Boekenhoutfontein Chrome Mine), Dunn (Manager of Brakspruit Platinum Mine), Meltzer (Manager of Swartkop Chrome Mine), Spence (Acting Manager of Swartklip Platinum Mine), Visser (formerly Manager of Rietfontein Chrome Mine), and Taeuber (administrator for the new company operating the last-mentioned mine), all of whom assisted him in every way possible.

Last but not least, all the farmers deserve his thanks for their hospitality during his stay on their premises.

II.—PHYSIOGRAPHY AND GENERAL GEOLOGY

A. PHYSIOGRAPHY

The area is characterised by a landscape of the inselberg type. Isolated hills as on Kookfontein 265 J.Q. and Vaalkop 275 J.Q. are dotted over flat country, which is at most places covered with black or reddish-brown soil and thornbush. Ridges of norite or pyroxenite, generally aligned parallel to the strike of the rocks, occasionally appear, as on Kroondal 304 J.Q., Rietfontein 338 J.Q. and Kafferskraal 342 J.Q. In a very few cases the chromitite seams are situated in or along the foot of such hills or ridges of norite or pyroxenite.

The drainage-lines over the area are directed chiefly to the north, e.g. Magatospruit, the Brakspruit, the Hex River and the Sterkstroom River, but in a few cases the trend is east, e.g. the Sand River.

B. GENERAL GEOLOGY

The majority of chromitite seams of the Bushveld Igneous Complex occur in the mafic rocks, which Hall (12) called the Critical Zone. The highest horizon at which the chromitite is known to occur is in the platiniferous, sulphide-bearing, felspathic pyroxenite just below the Merensky Reef, where it is generally present in the form of one or two very thin seams. The lowest seam of chromitite occurs in pyroxenite at a vertical distance of at least 4,000 feet below the Merensky Reef.

Investigation has shown that in a given profile across the mafic rocks of the complex, there may be at least 25 seams. In some cases it has been found that over certain distances the seams are more closely spaced than over others, so that a twofold but not a threefold grouping is possible, as is suggested by Kupferbürger *et al.* ([18], p. 9). This grouping is based on the fact that the lower and middle groups of seams are relatively near to each other, whereas the upper group is clearly separated from them. If based on the type of country-rock and the position in relation to definite markers, then a threefold division, as suggested by these authors, is feasible. For further details, see Chapter IV.

TABLE NO. 1

VERTICAL DISTANCES OF CHROMITE SEAMS IN FEET BELOW THE MERENSKY REEF

Locality	Horison		
	Upper Group	Middle Group	Lower Group*
Marikana-Rustenburg sector..........	560–820	970–1,830	1,140–2,190
Boshoek-Rustenburg sector..........	550–900	1,210–2,510	2,080–3,150

* The Main Seam, which forms a consistent marker in this group, was taken as datum.

The above table shows important differences in the position of the various groups in relation to the Merensky Reef.

The predominant rocks of that subdivision of the Bushveld Igneous Complex which was named Critical Zone by Hall ([12]) are pyroxenite, norite and anorthosite. The chromite seams are most frequently situated in pyroxenite; the overlying rocks are generally pyroxenite and the underlying rocks anorthosite, but the reverse is frequently the case. Seams also occur in anorthosite and, generally speaking, such seams are more distorted or broken than are those in pyroxenite (cf. plate I). Common norite or its felspathic varieties at places take the place of pyroxenite or anorthisite. According to Coertze ([4], p. 12) an "old" norite is intruded by "old" chromiferous pyroxenite. The latter is considered to be the parent-rock of the chromite. "Younger" norite and a porphyritic pyroxenite are again intrusive into the above-mentioned two "older" rock-types. The relationship between the porphyritic pyroxenite and "younger" norite is not clear. A coarse, granular pyroxenite, of which the relative age could not be definitely ascertained, also exists. Anorthositic varieties are associated with both the two mentioned types of norite. The porphyritic pyroxenite also contains chromitite seams, which Coertze considers to be xenoliths derived from the "old" chromiferous pyroxenite and incorporated by the "younger" porphyritic pyroxenite. Although he could find no direct proof of this, Coertze suggests a similar explanation for the presence of chromite in the anorthosite. A similar postulate was first put forward by Schwellnus ([24]) in connection with the mafic rocks of the Bushveld Igneous Complex in the north-eastern Transvaal.

The relation of chromite and silicates presents a rather difficult problem, and much has been written about the formation of the chromitite seams. The following is a synopsis of the different theories:—

Sampson ([22], p. 143) maintains that "there are only two processes which are not opposed by contradictory facts of miscroscopic study. These processes are the remelting of sorted crystals and to a limited extent, the separate intrusions of magma". According to the first theory, chromite crystals were formed at a higher and cooler level and sank down into a hotter level, where they were redissolved. In this way a layer of chromite liquid was formed, which on cooling crystallised *in situ* to form a chromitite seam. " The second theory, which seems to fit the facts, is the simultaneous formation of chromite and silicate from a residual solution . . . Given a sufficient amount of migration, this process may result in the actual intrusion of a chromite-rich magma."

Van der Walt (^{27}, p. 111) concludes " that the chromitite bands are derived from the same magma as the silicate rocks . . . it is assumed that the chromite bands were formed by the accumulation of crystals under the influence of gravity ". He also " confirms the theory that the rocks of the Bushveld Complex were derived from a series of magma inflows and not from one huge emplacement of magma. Further, it is shown that one influx of magma may be responsible for a series of chromitite bands. These were formed by intermittent crystallisation ".

Kuschke (^{19}, p. 79) states that " the bulk of the chromite is of early separation and crystallisation, but that some may be of a stage of consolidation later than that of the associated rhombic pyroxene ".

Fockema and Mendelssohn (^{10}, p. 81), however, suggest " that a small amount of chromite crystallized out at an early stage, which is found as small well-formed individuals within the interior of pyroxene crystals. This was followed, in the rocks being described, by the pyroxene, which in turn was followed by the major part of chromite from a chromite residual liquid ".

J. S. I. Schwellnus (^{24}, p. 102) also refers to veinlets of chromitite which project from the seams into the adjacent pyroxenite, but attributes the phenomenon to the intrusion of a variety of pyroxenite (so-called porphyritic pyroxenite) which is younger than the chromiferous pyroxenite, and during intrusion, " deformed and disrupted chromitite bands. In this way structures resembling an intrusive relationship of chromitite to chromiferous pyroxenite result ".

The last-mentioned author (p. 103) " is inclined to subscribe to the theory propounded by C. M. Schwellnus (1939, pp. 70–77), in which the Liesegang phenomenon is utilised for explaining the rhythmical formation of chromitite. According to this hypothesis the formation of chromitite was dependent upon physicochemical conditions and chromium was one of several elements which controlled the state of equilibrium in the magma. The separation of chromite resulted in the enrichment of the immediately overlying magma in magnesium, thus disturbing the equilibrium, which was then readjusted by the formation of magnesian orthopyroxene. C. M. Schwellnus favours the opinion that the chromite settled in the liquid form (1939, p. 171); a view supported by the present author as it would explain the origin of the chromite interstitial to the orthopyroxene ".

Chromitite lying in pyroxenite is most common in the lower group; where norite or its anorthositic varieties are associated with the chromitite, it generaly occurs in the middle and upper groups, but in some cases pyroxenite also occurs with the seams of the latter two groups.

The contact between chromitite and wall-rock may be sharp or transitional. Where the overlying rock of a chromitite seam is pyroxenite, disseminated chromitite occurs just above the seam, but where anorthosite underlies it, a zone of disseminated chromitite follows below the seam.

A pegmatitic variety of felspathic, micaceous pyroxenite is developed along the upper contact of the chromitite seam at places, but in some cases it traverses the seam and consequently contains remnants of the original seam. Pegmatite veins chiefly composed of quartz, alkali felspar

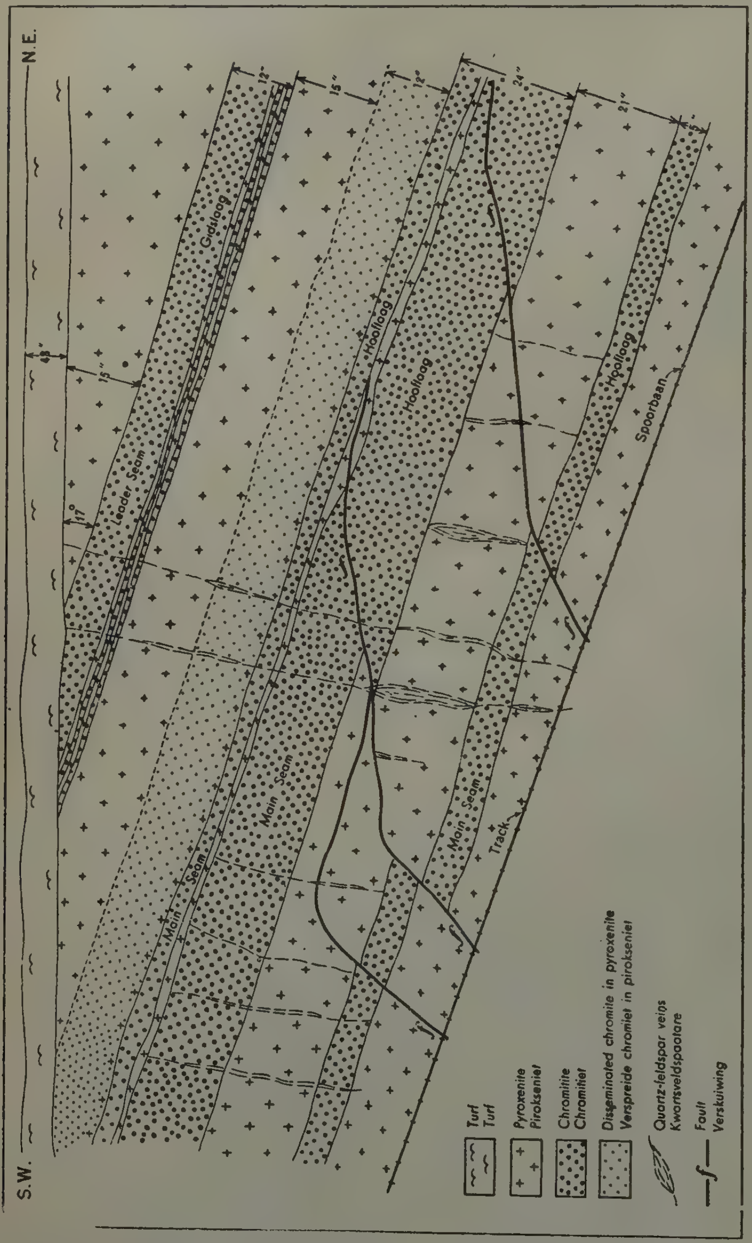

Fig. I.—Detailed section across "Main Horizon", as exposed along the collar-walls of inclined shaft, Bultfontein 259 J.Q.

Gedetailleerde profiel deur „Hoofhorison", soos blootgestel in wand van skuinsskag, Bultfontein 259 J.Q.

and mica cut both the chromitite and the country-rock, but they tend to become wider in the latter and peter out in the former, so that in some cases only a very narrow crack or joint in the chromitite indicates the continuation of these veins. They are presumably later than the faulting (see fig. 1).

In a prospecting-pit in the northwestern corner of Rietfontein 338 J.Q. pegmatitic, felspathic pyroxenite cuts across a chromitite seam; this intrusion was probably instrumental in tilting the chromitite practically vertically on the northern side, in contrast to the normal dip of the chromitite seam just south of the pegmatite.

An outcrop of chromitite, roughly oval-shaped in plan and approximately 4 by 14 feet in diameter, is associated with pegmatitic, felspathic pyroxenite in norite and is exposed in a stream on Boschfontein 268 J.Q. (see fig. 2). Whether this chromitite represents a geological window of a slightly folded seam, an inclusion or a segregation, could not be ascertained.

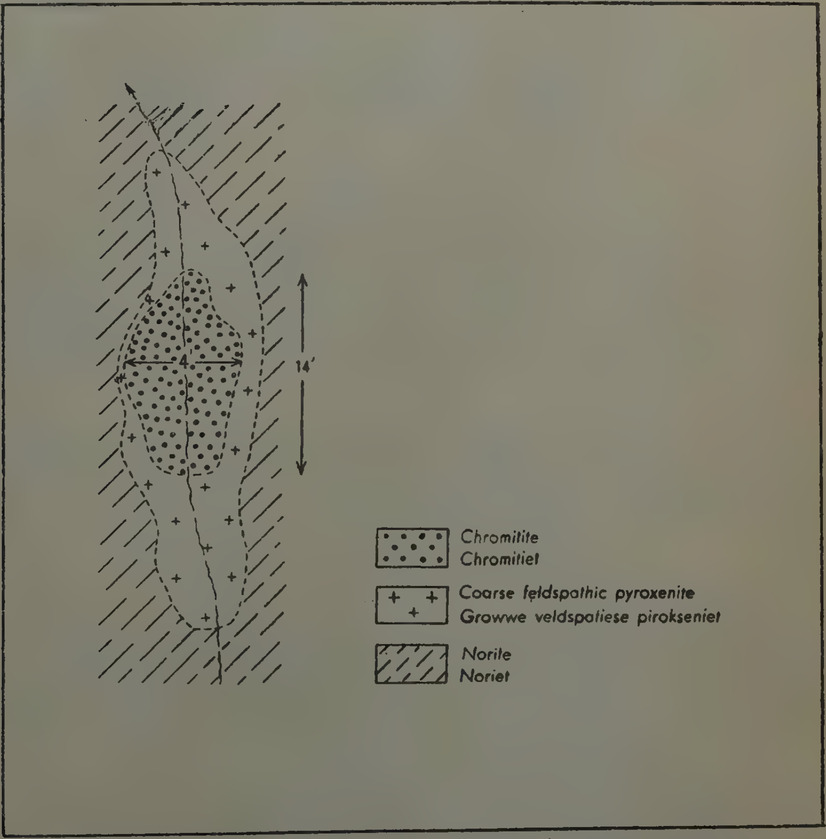
4'
14'
Chromitite
Chromitiet
Coarse feldspathic pyroxenite
Growwe veldspatiese pirokseniet
Norite
Noriet

Fig. II.—Plan of oval-shaped outcrop of chromite on Boschfontein 268 J.Q.
Plan van ovaalvormige dagsoom van chromiet op Boschfontein 268 J.Q.

Compared to the rest of the seam the thick chromitite seams generally show a less pronouncedly mottled appearance near to the base. This may explain the general opinion among miners that the ore of the basal portion of the seams are of the best quality.

The subdivision of the Bushveld Complex that contains the chromite seams is disposed in layers similar to the beds of a sedimentary formation, and this layering is known as pseudostratification. In the pyroxenite the chromitite seams conform to this pseudostratification, but owing to the fact that the seams are broken up at places when they occur in norite and anorthosite, it is occasionally difficult to determine such a parallelism. The seams show a remarkable lateral persistence (see chapter IV).

The normal regional dip of the chromitite seams ranges from 4° to 13° in a northerly to northeasterly direction. Abnormal gradients of from 20° to 90° also exist to a lesser extent. On Boschfontein 268 J.Q. a low-grade chromitite seam with a thickness of 12 inches dips 10° to 15° westwards, but in the Brakspruit on Spruitfontein 341 J.Q. the chromitite seams have an easterly and southeasterly dip.

Synclinal folding of chromitite is exposed in the bed of a stream on Turffontein 262 J.Q. (see fig. 3).

Minor structures ("rolls") are exposed in underground workings. According to the mine-plan the Main Seam on Kroondal 304 J.Q. has been locally folded into a basin-like structure. Unfortunately this portion of the mine is worked-out and inaccessible. A dome-shaped structure, approximately 6 feet in diameter, can be seen in chromitite next to the farm-road about 880 yards east of Pritchard's old workings on Kroondal 304 J.Q.

On the eastern portions of Spruitfontein 341 J.Q. and Brakspruit 299 J.Q. normal faulting with a downthrow on the eastern side of the syenite dyke has taken place. This faulting has displaced the Merensky Reef 950 yards laterally and has affected at least the upper group of chromitite seams. Near to the western boundary of Brakspruit 299 J.Q. a downthrow of 4 feet along the eastern side of a dolerite dyke caused a displacement in the Merensky Reef, but it is not known to what extent it affected the chromitite seams lower down.

Minor faults, which roughly parallel the strike of the chromitite seams, occur throughout the area and have a downthrow ranging from a few inches up to 3 feet, generally on the north-eastern sides of the fault. They are arranged en échelon at some places.

III.—DECRIPTION OF DEPOSITS

The chromite deposits of the area are known to occur only in the mafic rocks of the Bushveld Complex and to belong to a portion of the western chrome-bearing belt of the Transvaal. Unfortunately the area is largely covered by black and reddish-brown soil that obscures outcrops.

It is advisable to divide the area into two sectors:—

A. Rustenburg–Marikana Sector

This sector includes those occurrences between the Rustenburg railway station and 27° 30′ east longitude.

1. lower group of seams

These seams are all situated in pyroxenite and felspathic pyroxenite. The horizontal distance of the upper boundary of this group from the Merensky Reef ranges from 2,000 to 3,000 yards.

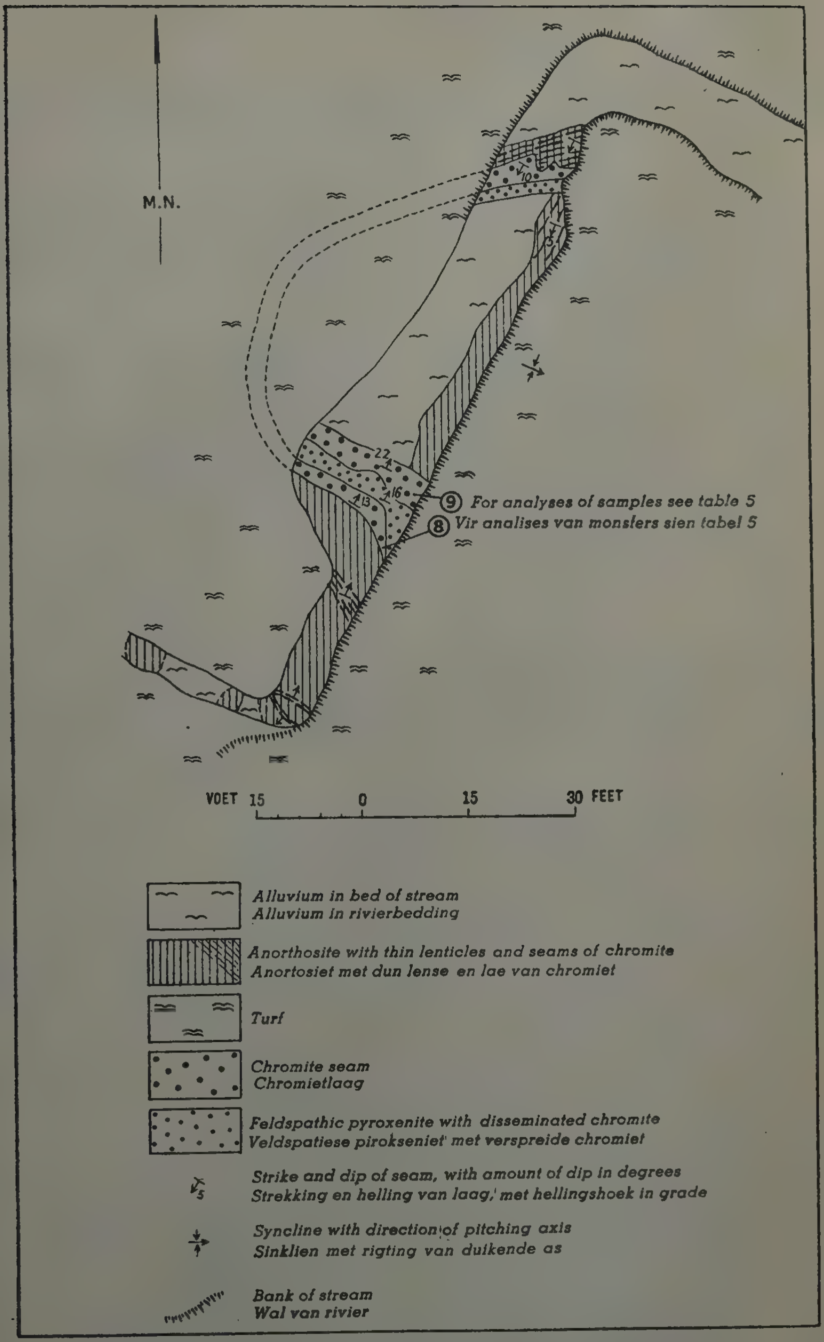
M.N.
10
5
22
16
13
⑨ For analyses of samples see table 5
⑧ Vir analises van monsters sien tabel 5
VOET 15
0
15
30 FEET
Alluvium in bed of stream
Alluvium in rivierbedding
Anorthosite with thin lenticles and seams of chromite
Anortosiet met dun lense en lae van chromiet
Turf
Chromite seam
Chromietlaag
Feldspathic pyroxenite with disseminated chromite
Veldspatiese piroksenie met verspreide chromiet
5
Strike and dip of seam, with amount of dip in degrees
Strekking en helling van laag, met hellingshoek in grade
Syncline with direction of pitching axis
Sinklien met rigting van duikende as
Bank of stream
Wal van rivier

Fig. III.—Plan of synclinal folding of chromite, Turffontein 262 J.Q.
Plan van sinklinale plooiing van chromiet Turffontein 262 J.Q.

Kafferskraal 342 *J.Q.*—The probable continuation of the seams exposed in the old workings along the eastern boundary of this farm, was struck in a bore-hole during drilling for water 50 yards east of the main road to Marikana. According to the owner, Mr. W. Rothman, the hole is 89 feet deep and chromite was encountered between 35 to 40 feet, 45 to 48 feet and 54 to 56 feet. A percussion drill was used, and therefore these results cannot be taken as true thicknesses.

Due west of this bore-hole chromitite was found in a prospecting-pit along the eastern bank of the Sterkstroom River. Owing to the presence of water and rubble in the pit, it could not be ascertained whether the chromite orginiated from float or a seam in situ. This locality is in line with the two above-mentioned localities and they are parallel to the general trend of the rocks.

Approximately 1,250 yards south of the above-mentioned prospecting pit and along the eastern bank of the Sterkstroom River, a low-grade chromitite seam, 12 inches thick, lies in felspathic pyroxenite.

Spruitfonaein 341 *J.Q.*—Float in gravel along the Brakspruit may be an indication of the presence of this group. Judging by the general trend of the Main Seam on Rietfontein 338 J.Q., this float may be located near to the possible extension of this seam.

Rietfotein 338 *J.Q.*—At least 11 seams, ranging in thickness from a fraction of an inch up to 50 inches, represent the group (see figures 4 and 5).

The Main Seam is being mined here at present and according to the Manager, Mr. Visser, the content of Cr_2O_3 ranges from 41 to 44 per cent. In a bore-hole belonging to Mr. W. Weinhold, a chormitite seam, approximately 6 feet thick, was struck at a depth of approximately 70 feet.

A fairly hard, lumpy seam of 18 inches is exposed in a prospecting-pit approximately 70 yards from the northwestern corner-post of this farm. This seam is probably the continuation of a similar one on Kroondal 304 J.Q., where is has been partially worked.

Rhenosterfotnein 336 *J.Q.*—A hundred yards south of the Pretoria–Rustenburg main road, a 4-inch seam is exposed over at least 150 yards across the bed of the stream. It is a fine-grained friable type (see table 3).

Kroondal 304 *J.Q.*—The most complete succession of this group hitherto known occurs here. As illustrated in folders 1 and 2, there may be as many as 15 seams in this group.

The Main Seam is at present being mined. In addition, seam 1 (see folder 2), which in general consists of hard, lumpy ore, but in places carries friable ore, may prove exploitable. This seam could be traced on the surface for at least 1,150 yards and probably continues to the north-western corner of Rietfontein 338 J.Q., where a similar seam can be seen in a prospecting-pit.

A 15-inch seam that dips 8° to 10° northwards in the Sand River may be the equivalent of either seam E or D (see folder 2). About 6 feet farther south and 12 inches lower, another exposure of chromitite can be seen under water. This might be a displaced portion of the above-mentioned or a separate seam.

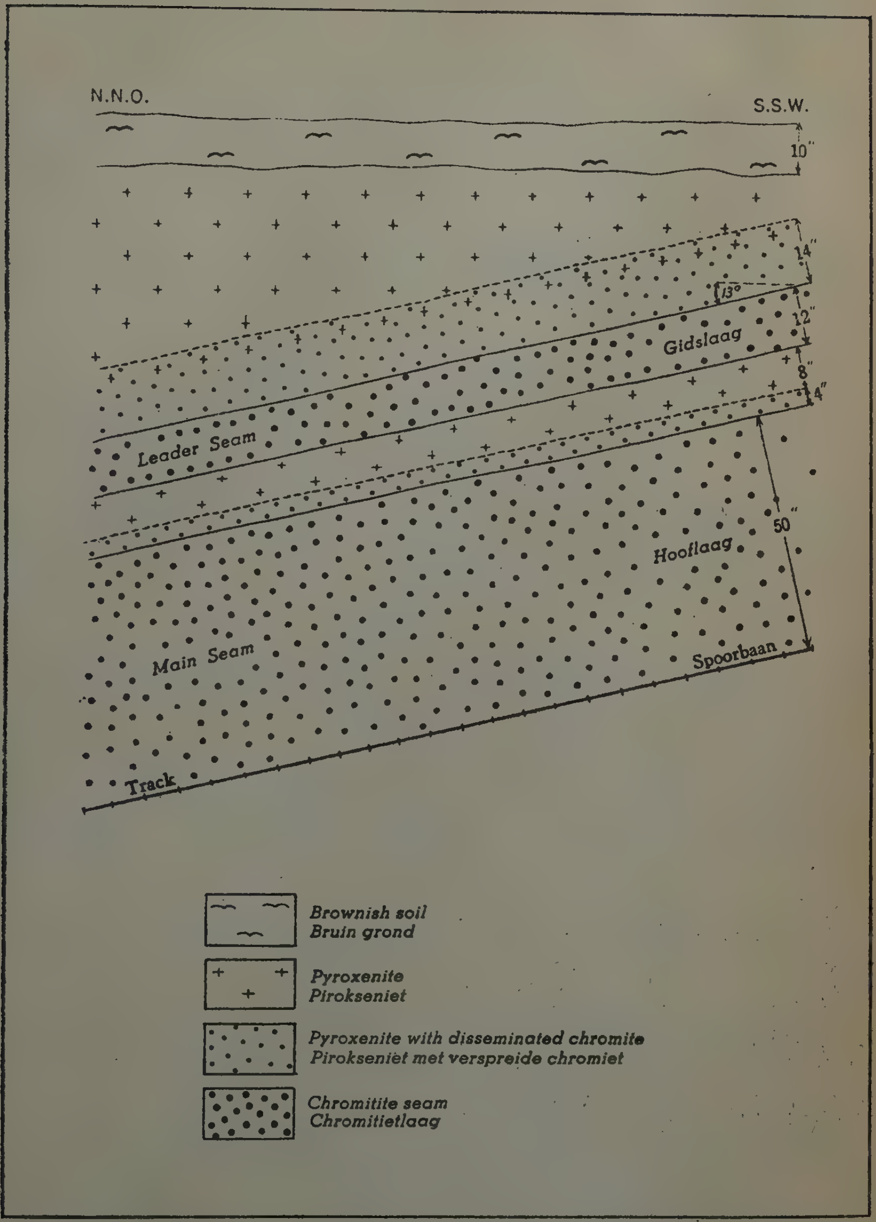

Fig. IV.—Detailed section across "Main Horizon" as exposed along the collar-sidewalls of Inclined Shaft, Rietfontein 338 J.Q.
Gedetailleerde profiel van die „ Hoofhorison " soos blootgelê aan die kante van die skuins skag 338 J.Q.

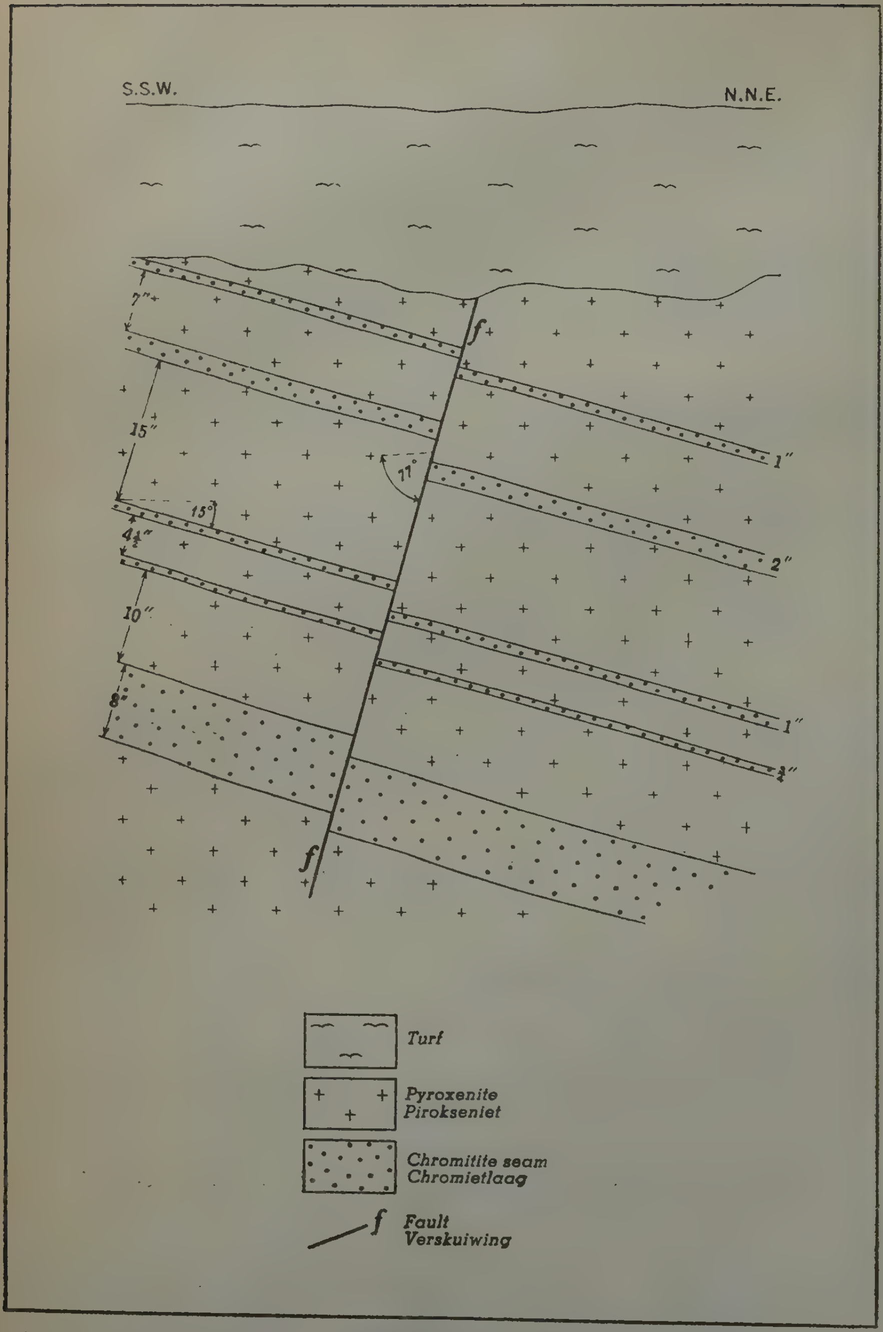

Fig. V.—Detailed section across "Roamer Horizon" as exposed in prosecting-trench on Rietfontein 338 J.Q.
Gedetailleerde profiel van die „ Roamerhorison " soos blootgelê in die soeksloot op Rietfontein 338 J.Q.

Waterkloof 305 *J.Q.*—In a quarry due west of the bridge across the Hex River, a succession of seams is exposed, as illustrated in folder 3. While planting trees, Mr. H. Klerck located a chromitite seam about 300 yards northeast of this quarry.

Along the southern edge of the main road, about 900 yards northwest of the bridge mentioned, a seam is exposed at the foot of a ridge of pyroxenite. The remnants of the seam can be seen along the dip-slope of the ridge. Ten yards north of the main road, a fairly low-grade seam 4 feet wide is exposed in the bed of a spruit.

Waterval 306 *J.Q.*—Ten seams of this group crop out in an intermittent tributary of the Hex River. A portion of folder 4 includes this locality.

2. MIDDLE GROUP OF SEAMS

The horizontal distance of this group of seams from the Merensky Reef ranges from 1,700 to 3,200 yards.

Kafferskraal 342 *J.Q.*—A hard and fine-grained chromitite is partially exposed along the western bank of the easternmost spruit 200 yards north of a farm road. It is associated with pyroxenite and the matrix consists mainly of uvarovite. On both sides of the above-mentioned farm-road anorthosite crops out, which serves as a very useful marker in correlating the middle and lower groups (see chapter IV).

Spruitfontein 341 *J.Q.*—Fairly low-grade seams are exposed in the Brakspruit, where they are associated with anorthosite and anorthositic norite, and to lesser extent with pyroxenite. Although the occurrences are about 1,000 yards apart, they may belong to what is essentially one horizon, because their direction of dip ranges from east to south-east, which means that the Brakspruit flows approximately parallel to their strike-direction. Owing to the scarcity of outcrops, the actual extent of this local disturbance could not be determined.

Brakspruit 299 *J.Q.*—An outcrop of chromiferous anorthosite in the south-western corner and chromitite float near to the southern boundary of this farm confirms the presence of a seam here.

Klipfontein 300 *J.Q.*—The continuation of the chromiferous anorthosite from Brakspruit 299 J.Q. can be seen in the southeastern corner. About 100 yards to the south thin seams occur in anorthositic norite.

Rietfontein 338 *J.Q.*—Isolated outcrops of chromitite seams in anorthosite occur all along the southern foot of the norite hill on which the trigonometrical beacon Rust 10 stands. Near to the north-eastern corner of the farm uvarovite is associated with the chromitite.

Kroondal 304 *J.Q.*—The most complete succession of this group hitherto known occurs here.

About 400 yards northeast of the mine's office-buildings an anorthositic norite is exposed in a circular dam. As it is only the main chromiferous pyroxenite that occurs below this point, it may be considered as the base of the middle group.

At least six seams, ranging in thickness from 8 to 51 inches, have been prospected in the past. The most prominent and promising one is associated with anorthosite (see fig. 6).

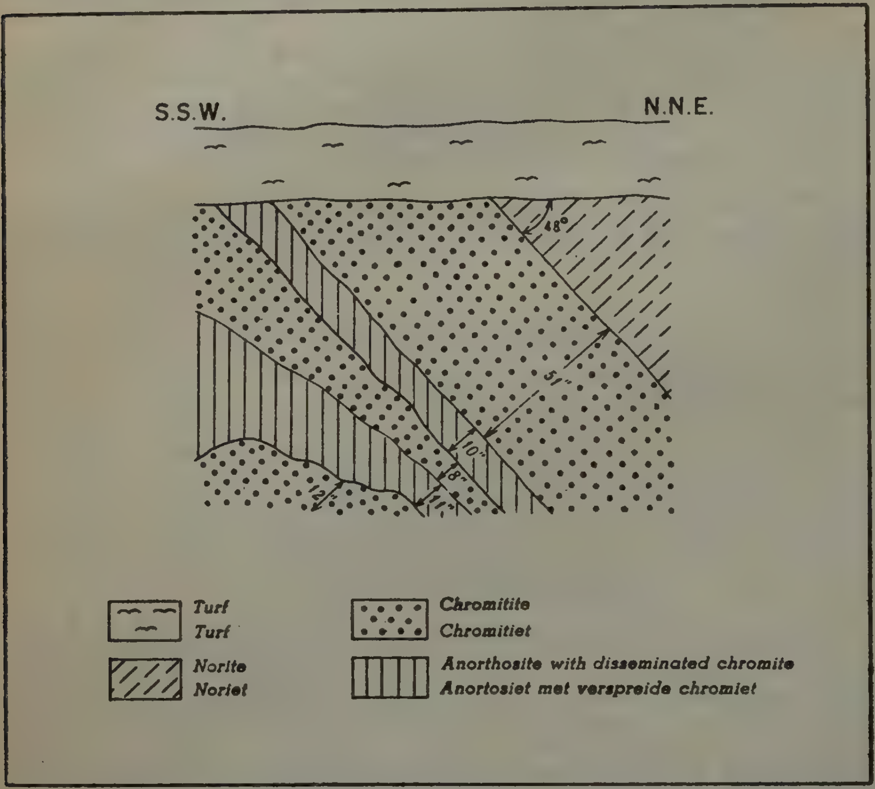
S.S.W.
N.N.E.
48°
51"
10"
8"
11"
12"
Turf
Turf
Chromitite
Chromitiet
Norite
Noriet
Anorthosite with disseminated chromite
Anortosiet met verspreide chromiet

Fig. VI.—Chromitite seams of the middle group in a prospecting-pit on Kroondal 304 J.Q.
Chromitietlae van die middelste groep in 'n prospekteergat op Kroondal 304 J.Q.

Two seams which occur with anorthosite and pyroxenite may also prove promising (see fig. 7).

Due east of the two seams and from 80 to 90 yards north of the road is an outcrop of chromiferous anorthosite that may represent the same horizon as that found on Rietfontein 290. About 1,000 yards west of figure 7 similar chromiferous anorthosite occurs and continues to the Sand River. Figure 8 is a sketch-map of an area a short distance to the east of this river.

Of these three seams, A is the most promising, but it is of fairly low grade. Seam C and the associated "banded" chromiferous anorthosite prove a valuable marker that can be traced from here for at least 1,800 yards eastwards.

Approximately 170 yards south of the above-mentioned marker a seam of 42 inches (D in fig. 8) is exposed along the northern embankment of an intermittent tributary of the Sand River. The hanging-wall is a spotted anorthositic norite and the foot-wall is anorthosite.

Waterkloof 305 *J.Q.*—All four seams that crop out in the bed of the tributary are of low grade. The southernmost is 8 feet wide, and norite occurs south of it. The other three outcrops are separated by 20 and 8 yards from each other and are associated with anorthosite.

Waterval 306 *J.Q.*—A low-grade seam approximately 200 feet wide crops out in anorthosite in the intermittent stream that joins the Hex River.

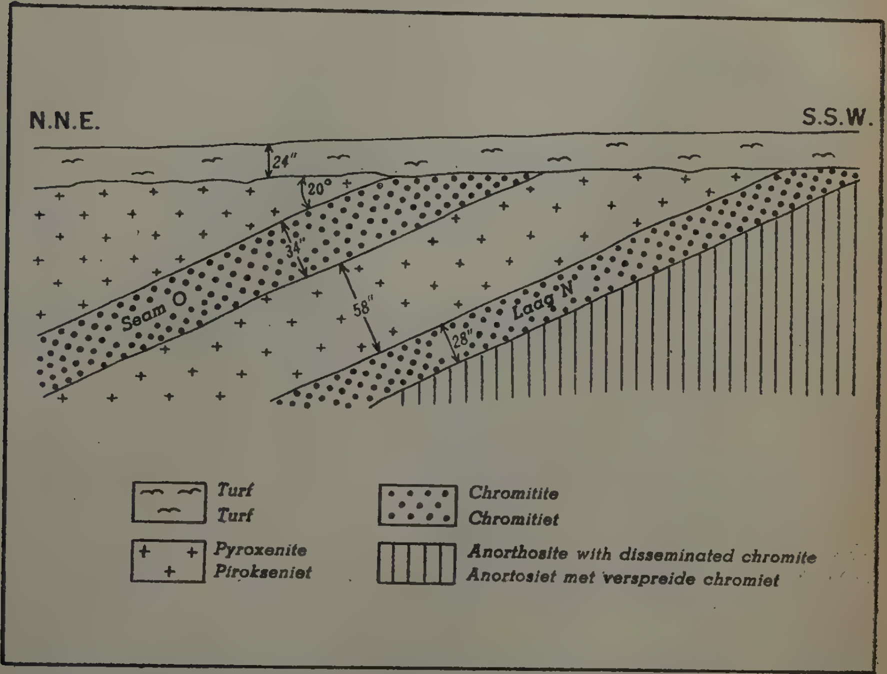

Fig. VII.—Chromitite seams of the middle group in a prospecting-trench on Kroondal 304 J.Q.
Chromitietlae van die middelgroep in 'n soeksloot op Kroondal 304 J.Q.

3. UPPER GROUP OF SEAMS

Except for a very thin seam that lies 75 yards south of the Merensky Reef on Rooikoppies 297 J.Q., the majority of the seams belonging to this group are located near to or in an anorthositic band. This very useful marker of anorthosite ranges in thickness from 50 to 200 yards and it can be traced all along the sector. Its horizontal distance from the Merensky Reef ranges from 500 to 1,500 yards.

Rooikoppies 297 *J.Q.*—The persence of this group is indicated by rubble in a land in the southeastern corner of the farm. The equivalent of this probable sub-outcrop has been found in a prospecting-pit in the bed of the eastern tributary of Brakspruit.

Kafferskraal 342 *J.Q.*—A low-grade seam was encountered just east of the main road while poles for the northern fence were planted.

Braksrpuit 299 *J.Q.*—According to the distribution of chromitite float and prospecting-pits, a seam of fine-grained, friable ore strikes for at least 1,400 yards from east to west. It may even continue for 700 yards farther west, because a seam of similar quality was found in the dry bed of a stream 270 yards west of the southernmost dunite pipe.

Klipfontein 300 *J.Q.*—About 200 yards west of the syenite dyke on the eastern portion of the farm, lenticular chromitite is present in anorthosite.

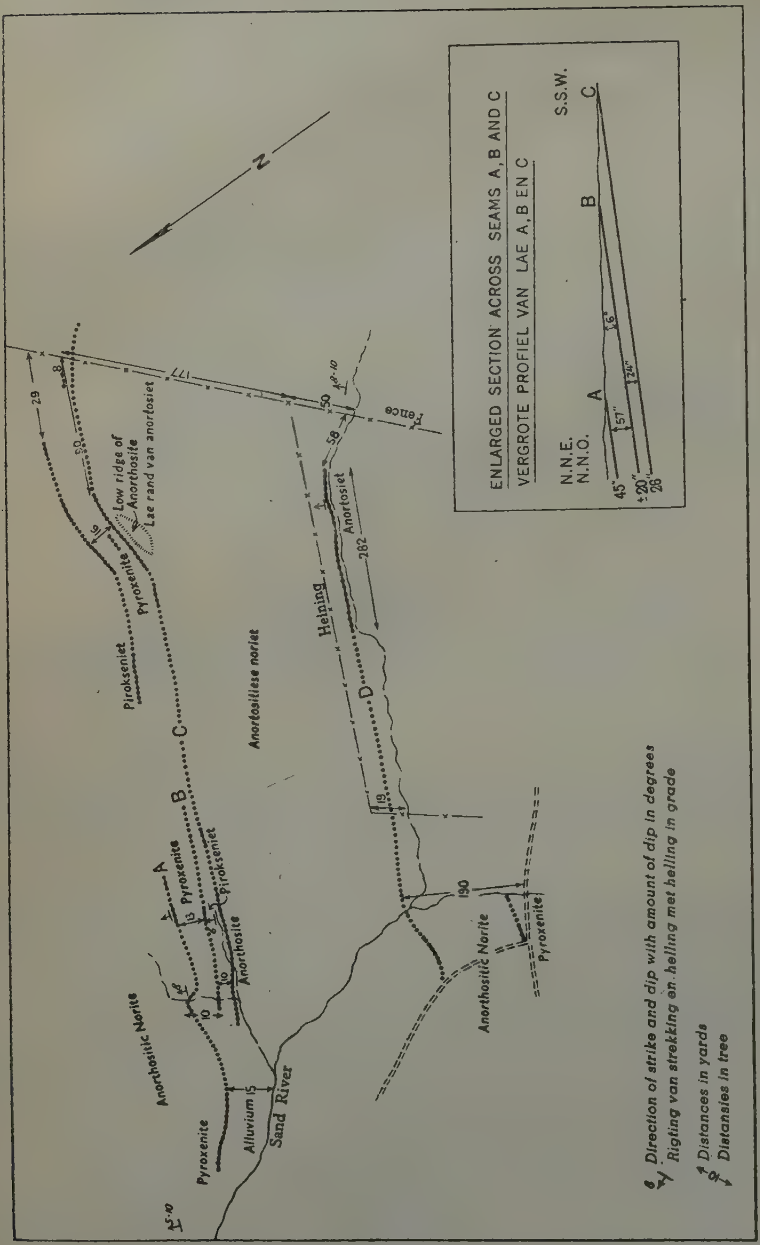

Fig. VIII.—Sketch-map of chromitite seams A, B, C and D of the middle group on Kroondal 304 J.Q.
Sketskaart van chromitietlae A, B, C en D van die middelste groep op Kroondal 304 J.Q.

Kroondal 304 *J.Q.*—Two seams about 50 wards apart, occur in anorthosite on the eastern extremity of the farm. The northern one is a fine-grained, hard lumpy ore of fairly promising quality, but it is poorly exposed and less than 12 inches thick. The southern occurrence consists of 12 thin lenses separated over a zone 6 to 8 inches wide.

Towards the middle of the farm, seams have been struck in six prospecting-pits. These are situated below the anorthosite marker, and are probably the continuation of those found at Pritchard's Old Workings.

The actual succession in the latter workings as illustrated by Kupferbürger *et al.* ([27], p. 18) could not be located, because all that could be seen were a 14-inch seam and a portion of the lower 30-inch band. A seam that is probably the same as the latter was found to reach a thickness of approximately 44 inches elsewhere in the vicinity.

Waterval 306 *J.Q.*—On the southern bank of the Hex River, thin seams occur in anorthosite, as illustrated in figure 9.

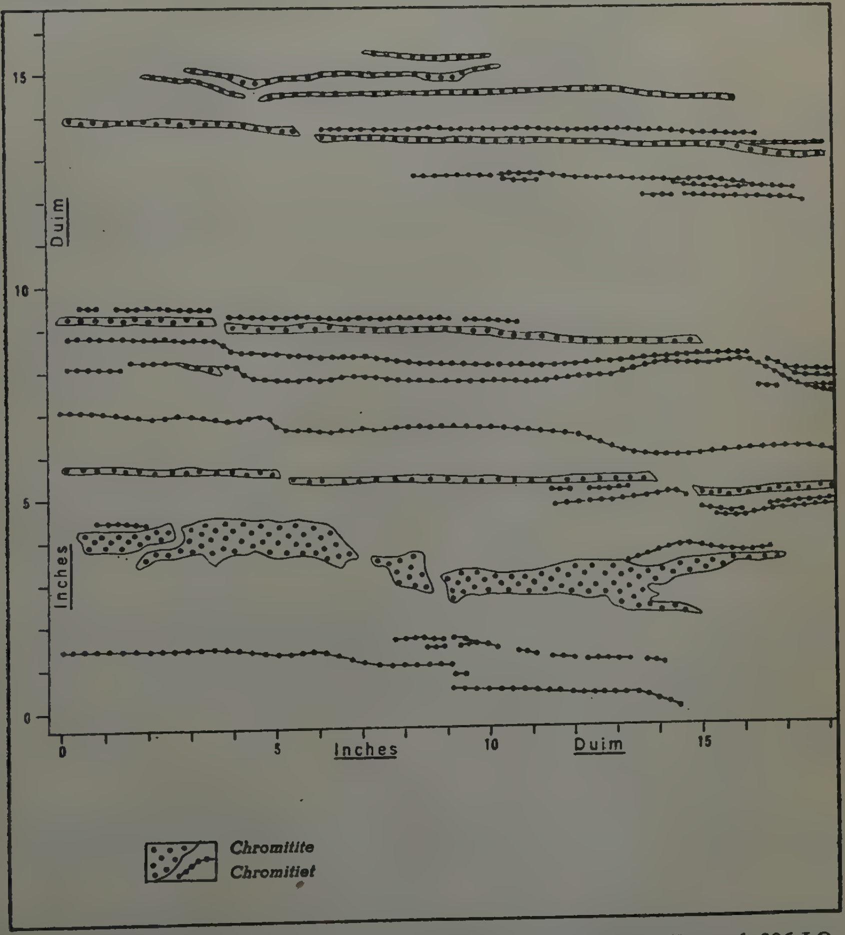

Fig. IX.—Chromitite of the upper group of seams in anorthosite on Waterval, 306 J.Q.
Chromitiet van die Boonste Groep Lae in anortosiet op Waterval, 306 J.Q.

B. RUSTENBURG–BOSHOEK SECTOR

All occurrences between the railway-stations of Rustenburg and Boshoek are treated in this section.

1. LOWER GROUP OF SEAMS

As is the case in the Rustenburg–Marikana sector, these seams are here located in pyroxenite and felspathic pyroxenite.

Boschfontein 268 *J.Q.*—A low-grade seam that dips 10° to 15° westwards is exposed in the eastern spruit. It is approximately 12 inches thick, but it has been split up into two thinner seams in some places. Although the direction of dip is abnormal, this seam lies in pyroxenite, so that it may tentatively be considered as belonging to this group.

Turffontein 262 *J.Q.*—In the bed of Magatospruit, 230 yards north of the railway-line, a chromitite seam at least 12 inches thick is partially exposed. Another 300 yards downstream a seam of 4 inches crops out along the western bank of the spruit.

Boekenhoutfontein 260 *J.Q.*—The Main and Leader Seams can be seen in the new mine as illustrated in figure 10. Only the former is at present being mined here.

The composition of samples from the workings are given in columns 1, 2 and 3 of table 3. For approximately 20 feet along the strike in the mine, the Main Seam attains a thickness of 6 feet. The chromic-oxide of this patch is said to average 39 per cent., but it is not known how far down the dip it extends.

By means of prospecting-pits just southeast of the mine, a concealed fault with a downthrow on the southern side has been located. It displaces the above two seams to a position just south of the railway-line. This horizon was prospected west of the mine and found to join up with the Main and Leader Seams in the Bultfontein mine.

A seam that is less than an inch thick and dips 50° to 55° northeast can be seen in a prospecting-trench against the slope of the pyroxenite ridge on which the trigonometrical beacon Rust. 68 stands. Prominent joints in the country-rock have a dip of 15° in the same direction.

Bultfontein 259 *J.Q.*—The Main and Leader Seams of this new mine have only recently been discovered (see figure 1). By way of a series of prospecting-trenches from the Boekenhoutfontein mine it could be determined that the Main Seam of the latter mine has here been split into a 24- and a 25-inch seam as illustrated in figure 1. Only the 24-inch seam is being mined here.

According to Mr. F. Fuls, owner of the farm and prospector of the seams, bore-hole No. 1 is 150 feet deep and two seams approximately 20 inches thick have been struck, one at 60 feet and the other at 90 feet.

Boshoek 103 *J.Q.*—A seam 1 inch thick and dipping 19° to the east is exposed in the bed of the stream. Farthur downstream, three seams respectively 2, 1 and 4 inches thick and separated over a band of 18 inches, dip 8° east. All four seams mentioned occur in pyroxenite.

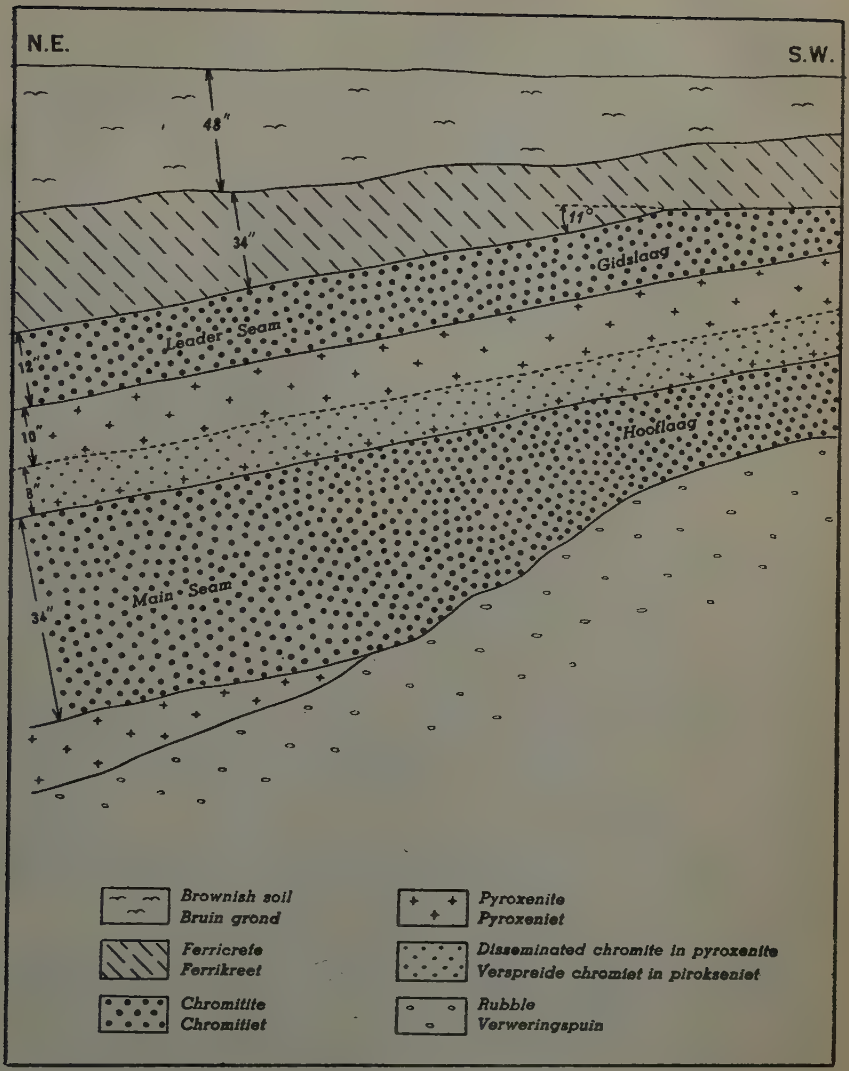

Fig. X.—Detailed section across "Main Horizon" as exposed along the collar-sidewalls of old inclined shaft, Boekenhoutfontein 260 J.Q.
Gedetailleerde profiel van die „Hoofhorison" soos blootgelê langs die kante van 'n ou skuinsskag op Boekenhoutfontein 260 J.Q.

2. MIDDLE GROUP OF SEAMS

The horizontal distance between the Merensky Reef and the seams belonging to this group ranges from 1,460 to 3,100 yards.

Boschfontein 268 *J.Q.*—Seams less than 1 inch thick occur 40 yards south of the railway-line and are the only exposures of this group. A short distance farther south along the same spruit, alternating bands of anorthositic norite and felspathic pyroxenite are practically vertical.

Kookfontein 265 *J.Q.*—While the Department of Irrigation was drilling a bore-hole for water (Geological Survey reference number G.8651), the following succession was pierced: 0 to 15 feet, red soil; 15 to 160 feet, norite; 160 to 176 feet, chromitite and 176 to 230 feet, norite. The sequence in a bore-hole (Department of Water Affairs number 58693) was as follows: 0 to 15 feet, turf; 15 to 48 feet, norite; 48 to 62 feet, chromite; 62 to 142 feet, norite and 142 tot 189 feet, chromite. As a percussion drill was employed, these results cannot be considered as true thicknesses of the chromitite seams.

Subsequent to the above discovery of chromite, two bore-holes, Nos. 1 and 2, were drilled by Cullinan Refractories, Ltd. Unfortunately the cores of both holes are incomplete, but judging from the cores available, boreholes 1 and 2 must be about 219 ft. 3 in. and 145 ft. 4 in. deep respectively. Both pierced norite; no chromite is to be seen in the core bore-hole No. 2, but two seams, 1 and 4 inches thick, were intersected in bore-hole No. 1 and the last 100 feet of norite pierced contains disseminations and schlieren of chromite. The schlieren generally show an abnormally steep dip.

According to Mr. F. W. Schumann, the sequence in a third bore-hole, No. 3, is as follows: 0 to 25 feet, weathered norite; 25 to 80 feet, anorthosite; 80 to 125 feet, noritic anorthosite and 125 to 150 feet, anorthosite.

West and southwest of the trigonometrical beacon Kookfontein 29 chromitite is exposed in prospecting-trenches. The chromitite in the western trench dips 15° to the east and consists of an upper seam of 12 inches underlain by 4 inches of norite and 8 inches of chromitite in descending order. Due south of the above-mentioned beacon chromitite in pyroxenite has been opened up. The nearby pyroxenite dips 31° southeast.

Beerfontein 263 *J.Q.*—The two southernmost occurrences of float along the spruit may originate from seams of this group.

Turffontein 262 *J.Q.*—About 400 yards east of the railway-line a seam of 3 inches is exposed for 21 yards along the bed of a stream. The southern portion of the chromitite outcrop lies in pyroxenite, but at the northern end the hanging-wall consists of anorthosite.

What appears to be two seams have been opened up in prospecting-trenches near to the western fence of the farm. In one trench a seam (with a thickness of at least 2 feet) is partially exposed.

Boekenhoutfontein 260 *J.Q.*—Cromite associated with norite and spotted anorthosite can be seen in two prospecting-pits in the northeastern corner of the farm.

Bultfontein 259 *J.Q.* (see folder 5).—The only indication of chromitite seams in this vicinity is scattered float around the old workings in the southeastern corner of the farm. According to Kupferbürger *et al.* ([27], p. 17): " The thickness of the seam ranges from 2½ to 4 feet and the ore is said to contain 38 per cent to 42 per cent Cr_2O_3. The foot-wall consists of anorthosite and the hanging-wall of pyroxenite."

About 200 yards northeast of a bore-hole a seam of 30 inches in norite can be seen in a prospecting-shaft.

Seventy yards north-northwest of the above-mentioned bore-hole another seam 33 inches thick is exposed in an old incline. The hanging- and foot-wall consist of norite and pyroxenite respectively.

Farther to the northwest on the same farm, chromite has been found in prospecting-pits now collapsed or filled in. These pits are situated along the possible continuation of the above-mentioned seams.

Chromite associated with pyroxenite occurs along the northern extremity of the farm.

Uitvalgrond 105 *J.Q.*—A seam 1½ inches thick crops out in pyroxenite, 125 yards west of the windmill.

Boskoppie 104 *J.Q.*—The seam partially exposed in a prospecting-trench is at least 8 inches thick.

Boshoek 103 *J.Q.*—A seam believed to be 30 inches thick is partially to be seen in the old workings. Disseminated chromite in norite has been found in a prospecting-pit 32 yards southwest of the southern corner beacon of Boskoppie 685.

3. UPPER GROUP OF SEAMS

The majority of the seams belonging to this group occur near to or in the same anorthositic band that exists all along the Rustenburg–Marikana sector. The width of this very useful marker ranges from 100 to 900 yards. Owing to the absence of outcrops its continuation could not be ascertained over a large part of Kookfontein 337. The anorthosite that crops out in the northern corner of the farm is presumably the extension of this band; from this point a band of anorthosite is continuous to Uitvalgrond 105 J.Q. A second and similar anorthosite band runs practically parallel to and just above the latter from Beerfontein 263 J.Q. to Uitvalgrond 105 J.Q., where the two seem to coalesce.

Rustenburg Townlands.—Northeast of the Rustenburg Location and the railway-line, a low-grade seam has been exposed in the bed of a stream for about 18 yards. According to the map of Kupferbürger *et al.* (18) this seam belongs to the lower group. Unfortunately this occurrence is not mentioned in the description, so that it appears as if their middle group must either be missing here or should still lie concealed between their lower and upper groups of seams. The latter suggestion does not seam acceptable. A correlation mistake or a misprint appears to be most likely. The float that occurs along the bed of the stream near the northwesterly fence of the townlands, may represent the same horizon.

Boschfontein 268 *J.Q.*—A seam of 4 inches that lies 7 inches above another of 6 inches dips 18° to the northeast in norite, which displays a pseudostratification with a dip of 23° in the same direction.

Another seam, 24 to 36 inches thick and having a footwall of basic pegmatite, occurs 42 inches below the above-mentioned two seams.

Kookfontein 265 *J.Q.*—A total of 10 seams, occurring over a distance of 170 yards, are exposed in the bed of the stream that flows near to the southeastern fence of the farm. The lower six seams range in thickness from 1 to 10 inches, and the outcrops of the upper four from 1 to 5 yards. Except for the most northeasterly two, which lie in norite, they occur in a felspathic pyroxenite. Some of these seams lie on Boschfontein 265 J.Q. as well as on Kookfontein 265 J.Q. and along the boundary between the two farms. Owing to the absence of a fence along this boundary, it is difficult to distinguish the actual boundary in the field. As the majority fall on Kookfontein 265 J.Q., they are all described here.

Fine washes of chromite can be seen in the sand all along a zone east to north-northeast of the trigonometrical beacon Kookfontein 29. Along this portion of the farm they seem to betray sub-outcrops that may represent the continuation of the above-mentioned ten seams. The seams which occur near to the northern fence of the farm are possibly a continuation of this group.

Beerfontein 263 *J.Q.*—A seam of 3 inches in the Magatospruit is the only exposure of this group, but judging by the multiplicity and the location of float, more seams are probably concealed and await discovery.

Turffontein 262 *J.Q.*—In the southern tributary of the Magatospruit two seams occur along a pitching syncline (see fig. 3). It will be noticed that along the northern limb of the syncline the upper seam consists of three thin seams. Chemical analyses of the two major seams are tabulated in table 5. The continuation of this syncline is partially exposed across the eastern fence of the farm, where the southern limb dips 17° to the northeast.

Farther downstream, along the same tributary of the Magatospruit, is a low-grade chromitite, the hanging-wall of which consists of norite and the foot-wall of anorthositic norite.

Three outcrops of low-grade chromitite associated with norite and pyroxenite are exposed along the bed of the northern tributary of the Magatospruit.

IV.—CORRELATION OF THE DEPOSITS

Wagner ([28], p. 66) first suggested that the chromitite deposits in the Rustenburg District could be separated into three "horizons", but apparently he referred to three individual seams and not to groups of seams. In his later Memoir 24 ([31], pp. 17–19) he definitely considers each "horizon" as a group of seams. Wasserstein ([32], pp. 218–220) attempted the correlation of different seams by comparing their relative vertical spacing. He eventually concluded: "It is realised that its applicability must be limited, but it remains a working hypothesis whose usefulness is still to be proved".

The subdivsion of the "Chromite sub-zone in the Critical Zone" as applied by Kupferbürger *et al.* ([15]) was mainly based on relative spacing between three similar groups and defined with reference to the Merensky Reef as datum. Unfortunately this criterion does not always hold good: it will be noticed from table 1 that an "overlap" can exist between the middle and lower groups if the vertical distances from the Merensky Reef are compared.

With reference to the lower and middle groups of seams along the Brits–Marikana sector, Kupferbürger *et al.* ([15], p. 15) admittedly state: "In view of the closely spaced nature of the seams the exact correlation with the three groups recognised elsewhere cannot be made until further exploratory work has been done."

The present correlation is based jointly on—

(1) type of country-rock;

(2) consistent markers;

(3) thickness of chromitite seams;

(4) observable, characteristic rhythms in the succession in the groups of chromitite seams.

A. LOWER GROUP OF SEAMS

Kupferbürger *et al.* ([15], p. 10) deduced that, "The instances in which chromitite lies in pyroxenite are most common in the lower group". The present investigation proved that a main body of chromiferous pyroxenite occurs mainly along the basal portion of that subdivision of the Bushveld Complex consisting of pyroxenite, norite and anorthosite. Above it, most of the chromitite occurs in norite and anorthosite and, to a lesser extent, also in pyroxenite. Therefore all seams that occur in this main chromiferous pyroxenite were allocated to this group.

The most conspicuous and important seams in this group constitute the "Main Horizon", which consists of a Main Horison and a Leader Seam. The former is the thickest of the lower group: it is the only known seam that exceeds 2 feet. It averages 36 to 40 inches in thickness, but attains 6 feet. From 8 to 18 inches above the Main Seam occurs the Leader, whose thickness ranges from 12 to 18 inches. Compare figures 1, 4, and 10, and folders 1, 2, 4 and 5.

The "Roamer Horizon", which consists of from 3 to 6 very thin seams, generally occurs a few feet below the Main Seam. It is amazing how this horizon repeats itself over widely separated distances. Compare figure 5 and folders 2 (BH1), 4 and 5. It must be mentioned here that although this horizon has not been noted in the logs of BH2, 3 and 4 (folder 2), it does not mean that it has not been penetrated, because in BH1 their actual positions are not definitely indicated and they have possibly been omitted from the logs of the rest of the bore-holes because of their minor importance from an economic point of view. This is the first characteristic horizon below the Main Seam at most places, and it may even prove to be a guide in locating that seam. All indications suggest that the three thin seams (2, 1 and 4 inches in thickness), as exposed on Boshoek 268, may also represent this horizon.

The two seams D and E are present on Kroondal 304 J.Q. and Waterval 306 J.Q. Compare folders 1, 2 (BH1, 2 and 3), 4, and 5.

It is quite obvious that the exposures of the "Main Horizon" in the mines at Bultfontein 259 J.Q., Boekenhoutfontein 260 J.Q., Kroondal 304 J.Q. and Rietfontein 338 J.Q. are all one and the same. It is possible that it persists over the major part of this long distance, but that depends on the existence over this stretch of that portion of the main chromiferous pyroxenite in which the horizon occurs.

According to Kupferbürger *et al.* ([18], p. 10), "From what is known it appears not unreasonable to suppose that the main seam persists from Steelpoort to Olifants River, a distance of 40 miles". Judging by the description of these authors the Main Seam of the eastern belt shows identical relationships and characteristics to that of the western belt.

Even the Magazine, Leader and Roamer Seams of Swartkop Mine (north of Northam) on the farms Swartkop 355 and Schildpadnest 233 show relationships similar to those of the above-mentioned Main, Leader and Roamer Seams of the Rustenburg area. The only difference is that the seams are relatively more widely spaced in that area. The possibility that the Magazine and Main Seams of these two areas, which lie 50 miles apart, may be correlated, is not far-fetched, as the data obtained on Palmietfontein 208 J.P. (on the western flank of Pilanesberg) seem to indicate that the Magazine and Garage Seams are the equivalent of the Magazine and Roamer Seams of the Swartkop area.

All the above evidence indicates that the "Main Horizon" may prove to be a persistent datum in the lower group.

Not until all the seams below the "Main Horizon" have been located can the base of the lower group, as defined by Lombaard ([20], p. 23) or Kupferbürger *et al.* ([18], p. 9), be ascertained.

Hall ([12], p. 275) states that the lower limit of the "Critical Zone" is much less definite, but may be drawn near to the lowest of the chromite horizons. For these reasons all the chromitite seams that occur below the "Main Horizon" and in the main chromiferous pyroxenite should belong to the lower group.

B. Middle Group of Seams

Near the upper limit of the lower group (which is the upper contact of the main chromiferous pyroxenite), two fairly closely spaced bands of anorthosite occur all along the Rustenburg–Marikana sector and a major part of the Rustenburg–Boshoek sector. They consist of a variety of clear, spotted and mottled anorthosite, and disseminated or faint bands and stringers of chromite are generally present in the outcrops. The anorthite content of these bands as determined by means of the universal stage is tabulated in table No. 2.

TABLE No. 2

ANORTHITE CONTENT OF DIFFERENT ANORTHOSITE MARKERS

Number of sample	Stratigraphical horizon	Locality	Percentage Anorthite Content	
			Variation	Average
GF 790..	Middle group of seams......	Kroondal 304 J.Q...	63–86	78·0
GF 792..	Middle group of seams......	Klipfontein 300 J.Q.	64–85	77·0
GF 793..	Middle group of seams......	Kroondal 304 J.Q...	78–84	80·4
GF 797..	Middle group of seams(?)....	Swartkop 355...... (Sht. 14)	78–85	82·4
GF	Upper group of seams.......	Turffontein 262 J.Q.	78–83	81·0
GF	Upper group of seams.......	Kroondal 304 J.Q...	64–85	77·7
GF 795..	Upper group of seams.......	Waterval 306 J.Q...	73–84	79·4
GF 796..	Upper group of seams.......	Brakspruit 299 J.Q..	78–84	79·2

Figures 6, 7 and 8 and folders 1 and 4 illustrate occurrences associated with this anorthosite marker. Seams A and B in figure 7 may be the same horizon as seams O and N in figure B, and the chromitite shown in figure 6 and seam D in figure 8 can be correlated.

The four seams on Waterkloof 305 J.Q. (see chapter III, A) seem to coincide with the four seams of figure 8. Seam L in folder 4 presumably represents the continuation of this same horizon.

C. UPPER GROUP OF SEAMS

The majority of seams belonging to this group occur near or in an anorthosite band, which can be followed practically right through the area. The colour of the anorthosite ranges from clear to spotted and mottled. At some places only faint streaks or disseminated specks of chromite in the anorthosite betray the possible presence of seams in the immediate vicinity (see pl. I and figs. 3 and 13).

In Pritchard's Old Workings on Kroondal 304 J.Q. a succession of this group lies just below the anorthosite marker. The seams that have been prospected farther eastwards on the same farm and Brakspruit 299 J.Q. also occur just below this anorthosite and may all represent the same horizon.

According to Kuferbürger *et al.* ([18], p. 19) " the bore-hole put down by the Tobacco Corporation just east of the railway station (Rustenburg) disclosed five seams spaced more or less like those of the above old Workings ".

The variation in the anorthite content of the above-mentioned anorthosite has been determined by means of the universal stage (see table 2).

The chromitite in the platiniferous, coarse, feldspathic pyroxenite that lies just below the Merensky Reef is considered to be the upper limit of the group, because this is the highest chromiferous horizon in the area.

V.—NATURE AND PROPERTIES OF THE ORE

A. CHEMICAL PROPERTIES

1. ANALYSES

Unless otherwise stated, all analyses are by C. E. G. Schutte and C. Lessing, Division of Chemical Services, Pretoria.

TABLE NO. 3

ANALYSES OF ORES FROM THE LOWER GROUP OF SEAMS

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
SiO_2	2·40	4·27	1·41	1·90	5·00	3·70	—	—	—	—	—	—	—	—	—	—	—	—	—
Cr_2O_3	44·39	43·25	46·20	42·10	38·20	38·30	46·90	46·90	47·30	47·10	45·70	45·70	45·20	45·40	44·70	44·80	45·60	46·40	46·10
FeO	24·93	24·55	25·27	24·20	23·30	23·20	25·50	25·90	25·90	25·90	26·10	26·10	26·10	26·60	26·20	26·20	28·70	28·10	29·10
Al_2O_3	17·72	16·20	15·60	n.d.	n.d.	n.d.	17·40	17·10	16·70	16·80	17·90	18·20	18·90	18·90	20·00	19·70	17·30	15·70	15·50
MgO	9·88	10·79	9·64	n.d.	n.d.	n.d.	10·20	10·10	10·10	10·20	10·30	10·00	9·80	9·10	9·10	9·30	8·40	9·80	9·30
CaO	0·34	Trace	Trace	n.d.	n.d.	n.d.	—	—	—	—	—	—	—	—	—	—	—	—	—
TiO_2	0·89	n.d.	n.d.	n.d.	n.d.	n.d.	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	100·55	99·06	98·12	68·20	66·50	65·20	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

1. Friable ore from Main Seam over 42 inches, 40 feet down old incline, Boekenhoutfontein 260 J.Q. Quoted from 5, p. 26. Analyst C. F. J. van der Walt.

2. Friable ore from Main Seam Boekenhoutfontein 260 J.Q. Analysed by Hyman's Laboratories, Johannesburg. Quoted from mine-manager, Mr. van Schalkwyk.

3. Do.

4. Friable ore from Main Seam 50 feet down easternmost incline, Bultfontein 259 J.Q.

5. Lumpy and friable ore from 16 inch seam, Kroondal 304 J.Q.

6. Friable ore from Main Seam along incline, Kroondal 304 J.Q.

7–13. Chromites, taken 6 inches apart from Main Seam Boekenhoutfontein 260 J.Q. No. 7 was taken at the base and No. 13 at the top. Quoted from 6, p. 84. Analyst, C. F. J. van der Walt.

14–17. Chromites, taken 6 inches apart from leader seam Boekenhoutfontein 260 J.Q. No. 14 was taken at the base and No. 17 at the top. Quoted from 6, p. 84. Analyst, C. F. J. van der Walt.

18–19. Chromites, from 4-inch seam on Rhenosterfontein 336 J.Q. No. 18 was taken at the base and No. 19 at the top. Quoted from 6, p. 85. Analyst, C. F. J. van der Walt.

TABLE No. 4

ANALYSES OF ORES FROM THE MIDDLE GROUP OF SEAMS

	1	2	3	4	5	6	7
SiO	0·60	6·00	13·80	7·00	3·90	1·00	1·60
$Cr\ O_2$	41·80	35·80	13·00	16·50	18·50	22·20	17·10
FeO	26·40	24·80	10·80	12·20	12·20	13·10	17·80
Total	68·80	66·60	37·60	35·70	34·60	36·30	36·50

1. Friable ore collected over 33 inches in old incline, Bultfontein 259 J.Q.
2. Friable ore from upper 20 inches of 45-inch seam, Kroondal 304 J.Q
3. Friable ore from lower 12 inches of 42-inch seam, Kroondal 304 J.Q.
4. Friable ore from 51-inch seam, Kroondal 304 J.Q. (see figure 10).
5. Friable ore from 28-inch seam, Kroondal 304 J.Q. (see figure 11).
6. Friable ore from 34-inch seam, Kroondal 304 J.Q. (see figure 11).
7. Friable ore collected over 8 inches of seam below 4, Kroondal 304 J.Q. (see figure 10).

TABLE No. 5

ANALYSES OF ORES FROM THE UPPER GROUP OF SEAMS

	1	2	3	4	5	6	7	8	9
SiO	5·00	3·30	5·80	5·30	6·30	1·90	5·70	1·90	2·00
$Cr\ O_2$	44·25	20·40	37·66	16·70	35·20	39·20	37·50	38·90	39·30
FeO	26·20	11·70	27·30	12·80	23·30	26·80	24·80	26·20	26·20
Al_2O_3	13·85	n.d.	19·01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
MgO	9·40	n.d.	8·66	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CaO	0·15	n.d.	1·66	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
TiO_2	—	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Total	98·85	35·40	100·09	34·80	64·80	67·90	68·00	67·00	67·50

1. Friable ore from Pritchard's Old Workings, Kroondal 304 J.Q. Also determined: $Fe\ O_2$ 0·50, $Na\ O$ trace, H_2O – 0·15. Quoted from 4, p. 230. Analyst, H.G. Weall.
2. Friable ore from upper 17 inches of 44-inch seam at Pritchard's Old Workings, Kroondal 304 J.Q.
3. Friable ore collected over 45 inches, in bend of spruit about 800 yards north-west of railway bridge, Boschfontein 268 J.Q. Quoted from 5, p. 27. Analyst, C. F. J. van der Walt.
4. Lumpy ore from Kroondal 304 J.Q.
5. Friable ore from isolated chromitite, 6 by 2 yards and approximately 9 inches thick, Kroondal 304 J.Q.
6. Friable ore from Brakspruit 299 J.Q.
7. Lumpy ore from Kookfontein 265 J.Q.
8. Friable ore from 9-inch seam, Turffontein 262 J.Q. (see fig. 3).
9. Friable ore from 16-inch seam, Turffontein 262 J.Q. (see fig. 3).

2. DISCUSSION

Judging by the analyses quoted, the chromite is in reality a complex mixture of chromite and picotite in which the proportion of the two minerals varies between rather wide limits. Other characteristics are a low content of silica, lime, titanium and phosphorus, and a high iron content.

De Wet ([7]) found that "the percentage of vanadium in Transvaal chromite ranges from 0·05 to 0·81 per cent. The analytical results indicate that the relationship between vanadium and total iron is sympathetic and antipathetic between vanadium and chromium".

According to Hall and Humphrey ([15], p. 75) and Wagner ([30], p. 234 and [29], p. 95), member of the platinum group of metals have been found in the chromitite in quantities ranging from nil to just less than 2 dwts. per short ton. Payable quantities of platinoids occur with chromitite in the coarse felspathic pyroxenite associated with the Merensky Reef.

The analyses indicate a considerable variation in the grade of the ore from place to place, even along the same seam. The ore may be classified as low to medium in grade.

According to Lombaard in a discussion on De Wet and Van Niekerk ([5], p. 21), "the disseminated ore has a composition different from that of the associated seams but resembles that of seams higher in the geological succession".

B. PHYSICAL PROPERTIES

1. MINERALOGY AND PETROGRAPHY OF THE CHROMITITE

The black lustrous crystals of chromite generally constitute the main mineral in the chromitite and the chief silicates present are bowlingite and orthopyroxene. Basic plagioclase, alkali feldspar, silica, magnesite, mica and uvarovite generally occur as gangue associated with the chromitite. For a more detailed description the reader is referred to Kupferbürger *et al.* ([18], p. 29-34).

An X-ray diffraction analysis* of the yellow to yellow-greenish silicate in the "Pseudo-porphyritic poikilitic" (mottled) areas of the ore indicates that these silcates may well be bowlingite, as suggested by the the above authors. The prominent, but not the fainter lines of the X-ray pattern correspond to those of saponite. Unfortunately an X-ray analysis of bowlingite is not available in the mineralogical laboratory of the Geological Survey. In any case the analysis indicates a variety of saponite that may be bowlingite.

2. INDUSTRIAL TYPES OF ORE

For industrial purposes the ore is classified on a physical basis as either friable or hard lumpy.

(*a*) *Friable*

This name is applied to ore that pulverises upon blasting and handling or exposure to the atmosphere. The bulk of the ore in the area belongs to this type. According to Van der Walt ([27], p. 93): "It was observed that when chromites are relatively free from silicates (i.e. crystallised before the pyroxenes) they are fairly coarse, due to slow cooling and crystallisation, and are friable."

(*b*) *Hard lumpy*

This variety of ore does not pulverise upon handling or exposure to the atmosphere. The demand for this type is usually greater, owing to the fact that it is much easier to transport, a minimum of loss occurring in comparison with the friable ore. It is found in small quantities and part of it may be naturally massive and the rest compressed.

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* By D. Groeneveld, Mineralogical Laboratory, Geological Survey, Pretoria.

(i) *Naturally massive ore.*—This type of ore is hard, because it lacks a granular structure. Isolated portions of a seam that is generally considered as friable, may be of this type. Van der Walt ([27], p. 93) concludes: "When the chromites and pyroxenes were formed simultaneously (chromitite contains a high percentage of silicates) the ore is hard and lumpy, and the crystals of chromite are very fine grained, due to rapid crystallisation."

(ii) *Compressed ore.*—Kupferbürger *et al.* ([15], p. 30) state: "where faults and minor earth movements have occurred, lumpy ore is found in seams which contain friable ore away from the disturbances. Among such lumps many are slickensided, but others bear no macroscopic evidence of compression." This has been found to be not true. On the contrary, most of the ore associated with faulting or folding in this area is friable, and the above statement is only true of a smaller number of cases.

VI.—FACTORS BEARING ON CONCENTRATION OF THE ORE

As concentration of the ore is mainly a metallurgical problem and various authors ([15], [37] and [17]) have already discussed the matter, a summary of the present state of concentrating chrome ore will suffice here.

It is known that the composition of the chromite varies considerably from place to place in the same deposit; therefore it is conceivable that there may be a similar variation from one crystal of chromite to another. If such a variation exists it would be important to be aware of it, as grains of poor quality may be removed during concentration and the possible loss during concentration of the grains of high grade may be avoided.

Lombaard ([18], p. 32) states that if such a variation does exist then it can be concluded that—

(i) the loss of chromite grains during washing does not take place selectively as far as the grade is concerned, i.e. the average composition of the chromite in the "slimes" is about the same as the average composition of the grains in the concentrate produced by the plant; or

(ii) the variation in composition of individual grains of chromite (if existing) bears no relationship to the size of the grains.

The inclusion of any of the associated minerals mentioned in chapter V, B will decrease the grade of the ore. The removal of bowlingite and pyroxene has a major effect on the composition of the concentrated ore, because they constitute the gangue most commonly present.

Bowlingite is more easily removed in the process of washing and hence pyroxene forms an important part of the remaining gangue in the washed ore.

Lombaard ([18], p. 37) found that roughly 1 per cent. of silica by weight of the ore cannot be removed by practical methods of concentration.

All the present mines except Kroondal concentrate their ore to a certain extent, so as to raise the quality.

According to the figures in the following table, supplied by the Manager of Boekenhoutfontein Mine, the content of chromic oxide can be increased by 2 to 2·9 per cent., by concentrating the ore.

TABLE NO. 6

COMPARISON BETWEEN RUN-OF-MINE ORE AND CONCENTRATIONS OF BOEKENHOUTFONTEIN MINE

Date of sampling	Run-of-mine ore			Concentrates		
	Cr_2O_3	SiO_2	FeO	Cr_2O_3	SiO_2	FeO
11/9/1954................	43·28	5·32	24·65	—	—	—
18/9/1954................	—	—	—	46·18	—	—
25/9/1954................	—	—	—	45·91	—	—
2/10/1954................	—	—	—	46·08	1·71	25·50
2/10/1954................	43·69	3·60	24·94	—	—	—
9/10/1954................	—	—	—	45·63	—	—
23/12/1954...............	—	—	—	45·68	—	—

According to Lombaard ([18], p. 37) " experiments in the laboratory as well as results obtained in practical concentration suggest that it is not unreasonable to expect the concentrated products to assay between 1 per cent. and 2 per cent. of silica. It follows then that the higher the content of silica in the chromitite the greater will be the amount of gangue and the greater will be the increase in the chromic oxide content resulting from the removal of that gangue ".

The owner of Bultfontein Mine, Mr. Bauristhene, maintains that by merely washing the fines from the mine in a concentrating pan of 8 feet in diameter, the content of chromic oxide of medium-grade ore is increased by 3 to 4 per cent., whereas the low-grade (37–39 per cent.) material is enriched by approximately 10 per cent. This high percentage of concentration he attributes mainly to the speed of rotation and the orientation of the blades attached to the concentrating pan. According to him the pan makes 15 revolutions per minute.

At Rietfontein Mine the same method of concentration as the abovementioned is employed on ore with a chromic oxide content ranging from 39 to 40 per cent., and according to the Manager, Mr. Visser, the grade is improved by approximately 1·5 per cent.

It is quite obvious that a consistent grade can be obtained by means of suitable treatment, and as the processes improve, wide seams of lower grade are brought within range of economic exploitation.

VIII.—PRODUCTION AND MARKETING

A. MINING

After the discovery of the Main Seam on Bultfontein 259 J.Q., active mining has taken place here since June, 1955. Three inclines have been sunk; at present the easternmost of these serves the mine. Production started when this shaft reached approximately 150 feet down the incline. According to Wagner ([31], p. 17), the Western Chrome Company has in the past exported 200 tons per month from the northern part of the farm.

A fair amount of surface quarrying and underground mining has taken place on Boekenhoutfontein 260 J.Q. The property was taken over from the Western Chrome Company, Ltd., in 1929. In March, 1931, the Chrome Corporation (S.A.), Ltd. started production. A long period of inactivity followed, but since 1953 this company has commenced underground mining again. The maximum depth reached at present is approximately 700 feet down the incline. Approximately 400 short tons of washed ore are produced daily at a cost of 20 to 25 shillings per short ton (transport and concentrating expenditure excluded).

Marble, Lime & Associated Industries, Ltd., started mining on Kroondal 304 J.Q. in about 1947. Three inclines serve the mine, and the average daily production is 250 short tons. No concentrating is done here. Two-thirds of the production goes for local consumption by the company; the rest is exported. The average cost of production per short ton amounts to 15s. 6d. (railway-rates excluded).

In about 1949 the first incline was sunk on Rietfontein 338 J.Q. Soon afterwards production stopped, but Pondoland Minerals (Pty.), Ltd. resumed mining again in 1954. Three inclines exist on their property, but only the westernmost was producing during the author's visit in June, 1955. It had then reached a depth of approximately 300 feet down the incline. A fourth shaft (of Mr. Zeeman) was also being sunk on the same farm, but just east of the above property. In the meantime the whole of Rietfontein 338 J.Q. was taken over by the J.G. Farbenfabrieken, Bayer (Germany), with Taeuber and Corssen (Pty.), Ltd., as their administrators. During the author's last visit to the farm in June, 1956, a new lay-out was being erected in the centre of the farm.

Prospecting on Kookfontein 265 J.Q. is at present (1956) being undertaken by Cullinan Refractories, Ltd.

A certain amount of ore is recovered by surface stripping along the outcrops in the initial stages of the opening up of a prospect, and the rest by mining at a few hundred feet from the surface. In this flat country the mining is done by a pillar-and-stall method of stoping from winzes. At present the new mining company on Rietfontein 338 J.Q. is mining both the Main and Leader Seams, but none of the other mines in the area exploit the latter seam.

The Main Seam averages about 38 inches in thickness, which provides an adequate stoping width. Generally there is a well-defined hanging- and foot-wall of pyroxenite, so that clean mining of the chrome ore is possible at most places. Should the width of the seam be less than 12 inches, mining takes place by means of resuing: about 2 feet of the hanging-wall pyroxenite is broken, all the broken rock is thoroughly removed, and the thin chromitite seam in the foot-wall is picked up. In both methods of mining contamination of the ore is inevitable and the grade of the run-of-mine ore is lowered.

B. TRANSPORT

Besides the grade of the ore, the most important consideration for the exploitation of chromite deposits is undoubtedly that of transport facilities and accessibility to the existing railway-system.

This area is very favourably situated with regard to railway transport: the Thabazimbi–Pretoria railway-line runs more or less parallel to the strike of the chromitite seams, and on Bultfontein and Boekenhoutfontein it is very near the mines. The loading place of ore from these two farms is Boshoek railway-station. The major part of the distance to this station is served by an excellent asphalt road. The ore from Kroondal and Rietfontein mines is loaded at Rustenburg, use being made of the Pretoria–Rustenburg main road over the major portion of this distance.

C. OUTPUT.

Since 1921, when chromite first began to figure among the regular mineral exports of the Union, a steady increase in production has taken place. It is now one of the major base mineral products of the Union.

Statistics of the annual production of chromite for this area are given below.

TABLE NO. 7

PRODUCTION OF CHROMITITE FROM THE RUSTENBURG AREA

Year	Farm	Tons (2,000 lb.)
1924	Boekenhoutfontein 260 J.Q.	1,600 (Kroondal 304 J.Q. included)
1925	”	No production.
1926	”	No production.
1927	”	3,718.
1928	”	16,779 (Bultfontein 259 J.Q. included).
1929	”	16,026.
1930	”	1,699.
1931	”	No production.
1932	”	5,550 (Various other farms included).
1933–1952.	”	No production
1953	”	2,128.
1954	”	10,867.
1955	”	14,941.
1953	Rietfontein 338 J.Q.	14,800.
1954	”	12,501.
1955	”	19,225.
1924	Kroondal 304 J.Q.	1,600.
1932	”	116.
1933	”	139.
1934	”	71.
1947	”	388.
1948	”	17,058.
1949	”	23,924.
1950	”	14,362.
1951	”	24,720.
1952	”	32,316.
1953	”	55,922.
1954	”	42,610.
1955	”	64,077.
1953	Bultfontein 259 J.Q.	No production.
1954	”	No production.
1955	”	606.
	Total	397,743.

1. GRADES OF ORE

Chrome ore is graded roughly according to its use for metallurgical, refractory or chemical purposes. According to Kahn and Schady (17, p. 247) the world consumption is as follows: ferrochromium production, 45 per cent.; refractory production, 40 per cent.; chemical production, 15 per cent.

Ferrochrome producers require a hard lumpy ore containing not less than 48 per cent. chromic oxide and a Cr to Fe ratio not less than 3:1. During World War II, when supplies of metallurgical ores were restricted, specifications were lowered to 45 per cent. chromic oxide, with a Cr to Fe ratio of 2·5 : 1.

Refractory ores are relatively high in chromic oxide and alumina, but low in iron and silica.

Generally speaking, the poorer grade ores that are unsuitable for the above two purposes, are used for chemical purposes. They should be as high in chromic oxide and as low in silica and alumina as possible. Specifications are rather more variable and less rigid than in the case of metallurgical and refractory grades, and are generally determined on a basis which takes into account availability and price. It follows that the price obtained for chemical grade ores is quite considerably lower than for the other grades.

Typical analyses of chemical, metallurgical and refractory grade ores are shown in table 8, as quoted from Kahn and Schady (17, p. 247).

TABLE NO. 8

TYPICAL ANALYSES OF THE THREE TYPES OF CHROME ORE

Constituent	Refractory		Chemical		Metallurgical	
	Cuba	Philippines	New Caledonia	Transvaal	Rhodesia	Turkey
Cr_2O_3	31·0	34·2	46·4	44·6	49·9	48·8
Fe	12·4	10·7	9·8	19·6	11·5	11·0
Al_2O_3	27·4	30·3	16·0	15·7	11·1	12·5
MgO	17·0	16·5	17·8	10·0	15·9	16·8
SiO_2	5·3	3·5	4·6	3·2	6·4	4·4
Cr: Fe	1·7	2·2	3·2	1·5	3·0	3·0

Judging by the above analyses the chromite of this area is of low grade and is used mainly in the chemical industry.

D. Other Economic Factors

As the unbeneficiated chromite is suitable only for the production of chemicals, for which purpose only 15 per cent. of the world consumption of chromite is consumed, it goes without saying that only after some method of beneficiation is utilised can the ores be made suitable for metallurgical and refractory purposes.

According to Smit (^{25}, p. 294) the Transvaal ore is superior to the Rhodesian chromite in the following respects: Transvaal ore is much less refractory and can be smelted in the electric furnace at a faster rate and with a lower flux addition. The best domestic ore contains 28 per cent. slag-forming elements, compared with 37 per cent. in Rhodesian ore. Owing to this high percentage of slag-forming elements, 20 per cent. more Rhodesian ore than Transvaal ore is required for every ton of alloy produced. The grade of the product is, however, 60–65 per cent., whereas the normal overseas grade is 65–70 per cent., but the cost per unit of chromium is must less when using domestic ores.

An alloy that is finding increasing use in the production of stainless steel directly from the ore is produced by means of a process devised and used by African Metals Corp., Ltd. Here the Cr:Fe ratio is of no material importance. The Union of South Africa can make some of the cheapest stainless steel in the world by exploiting such a process on a large scale by means of a completely integrated works.

It is always possible that users of chromite will in the distant future be forced to accept lower grade ore when supplies of the higher grades become depleted. But except in times of war or in the event of some other emergency it seems unlikely that this will apply to chromite, as the available reserves of suitable grade of ore are considerable.

The American consumer, to whom the greater portion of Transvaal chromite finds its way, is continually investigating methods by which all types of ores can be used. The result of these investigations is that they bring within the range of economic exploration many large deposits that are low in grade but occur in wider seams, which means that ore can be marketed at a lower price.

E. ORE-RESERVES

Before estimating the reserves of chromite a thorough knowledge of the continuity and mode of occurrence of the deposits should first be obtained.

As two different generations of pyroxenite and norite may exist (see chapter II, B), an intimate knowledge of such possible relationships must be available before an accurate ore-reserve can be calculated, because the younger norite and porphyritic pyroxenite that are believed to be intrusive into the older norite and main chromiferous pyroxenite may be responsible for discontinuities in, or localisation of the chromite seams.

Owing to the scarcity of outcrops in this flat, soil-covered area, it is sometimes impossible to determine the exact interrelationships between the chromite seams and country-rock over long distances. The only means of ascertaining the possibilities, is by systematic prospecting, including drilling.

If it is assumed that the Main Seam of the lower group exists at least wherever that portion of the main chromiferous pyroxenite occurs wherein it can be expected (see chapter IV), a fairly accurate estimation of this important seam can be made.

If it is assumed that the depth down the dip of the seam is 500 feet, the average thickness 30 inches and the specific gravity 3·8, then the available reserves over a total distance of 25 miles amounts to 19,550,000 short tons. Of this probable reserve, approximately 800,000 short tons has been mined out already.

VIII.—CONCLUSIONS

1. It seems possible to subdivide the portion of the Bushveld Complex formerly called the Critical Zone by means of definite and persistent horizons and markers.

2. The present method of correlation might prove to be of similar value outside the area.

3. At least the possibility of the continuity of an economically important and persistent marker in the lower group, the " Main Horizon ", has been tentatively established. This might prove a valuable datum in the future. Systematic prospecting and drilling in the area will confirm such an opinion. A magnetometrical survey proved unsuccessful in tracing the different chromite seams.

4. Near to the base of the middle group there exists a thick seam exceeding 2 feet in thickness. If the Main Seam can persist over long distances, this seam may also show similar tendencies. Unfortunately it might have been subjected to a large-scale disruption caused by the intrusion of the younger norite and porphyritic pyroxenite.

5. The chromitite in general may be considered as low-grade; the lower group contains the best quality of ore.

DIE CHROMIETAFSETTINGS IN DIE GEBIED RUSTENBURG

OPSOMMING IN AFRIKAANS

deur

F. A. Venter, M.Sc.

INLEIDING

Reeds in 1865 het C. Mauch die aanwesigheid van chromiet naby die Hexrivier op 'n kaart aangewys. Sedertdien het 'n hele paar skrywers in artikels wat in die bibliografie aangegee word, melding gemaak van die voorkomste.

Die gegewens in hierdie bulletin vervat is ingesamel gedurende 'n ondersoek wat in 1955 uitgevoer is met die doel om 'n verslag oor die ekonomiese geologie van Gebied 4 (Rustenburg) op te stel. Deurdat meer gegewens ingesamel is omtrent die chromiet as wat oorspronklik beoog is, het die publisering van hierdie bulletin moontlik geword. Die belangrikheid van die afsettings as 'n huidige en toekomstige bron van ontginning van chromiet word beklemtoon en daar word gepoog om die beskikbare gegewens op so 'n wyse saam te vat dat dit van nut sal wees vir toekomstige prospekteerwerk.

Alhoewel die benaming „Chromiet" mineralogies nie streng gesproke korrek is nie, word dit in hierdie verslag gebruik vir die mineraal bestaande uit Cr_2O_3, FeO, $A1_20_3$ en MgO.

FISIOGRAFIE EN ALGEMENE GEOLOGIE

Die gebied is plat en is 'n tipiese inselberglandskap met uitstaande koppies. Dit is bedek met swart of rooi-bruin grond waarop doringbosse groei. Heuwels wat uit noriet of pirokseniet bestaan en wat parallel aan die strekkingrigting van die rotse is, kom plek-plek voor. Die dreinering is noordwaarts en die vernaamste riviere is die Hex- en Sterkstroomrivier.

Die meerderheid van die chromietlae van die Stollingskompleks Bosveld kom voor in die „Kritieke Sone", die middelste van die vyf sones waarin die mafiese gesteentes voorheen ingedeel is. Die hoogste, dun chromietlaag verskyn net onderkant die platinumdraende Merenskyrif. Die onderste laag kom omtrent 4,000 vt. onderkant die genoemde rif voor. Op sommige plekke is 25 chromietlae waargeneem en op plekke is hulle baie dig bymekaar, en op so 'n wyse gespasieer dat 'n tweevoudige indeling geregverdig is, en nie 'n drieledige, soos deur vorige waarnemers voorgestel nie. Die volgende tabel gee insig in die indeling:—

VERTIKALE HOOGTES VAN CHROMIETLAE IN VOETE ONDERKANT DIE MERENSKYRIF

Plek	Horison		
	Boonste groep	Middelste groep	Onderste groep
Marikana-Rustenburg-sektor.........	560–820	970–1,830	1,140–2,190
Boshoek-Rustenburg-sektor..........	550–900	1,210–2,510	2,080–3,150

Die vernaamste rotssoorte in dié gedeelte van die Bosveldkompleks waarin die chromiet voorkom, is piroksiniet, noriet en anortosiet. Die chromietlae word in die meeste gevalle in die piroksiniet gevind, veral in die geval van die onderste groep lae. Anortosiet gaan op die meeste plekke gepaard met die middelste en boonste groepe.

Verskeie teorië oor die ontstaan van die chromietlae deur verskillende navorsers word bespreek. C. M. Schwellnus (23) is van mening dat die chromiet in 'n vloeibare vorm afgesak het in die magma en die skrywer ondersteun hierdie teorie.

Die kontak tussen die chromitiet en die wandgesteentes is òf skerp òf geleidelik. As die dak van die laag uit piroksiniet bestaan, word verspreide chromitiet net bokant die laag aangetref en wanneer die vloer uit anortosiet bestaan, kom 'n verspreide sone van chromitiet weer net onderkant die laag voor. Die noriet, piroksiniet en anortosiet kom voor in lae net soos dié van afsettingsgesteentes. Die chromietlae volg ook hierdie pseudostratifikasie, is sydelings standhoudend, en het 'n regionale helling van 4° tot 13° in 'n noordelike tot noordoostelike rigting. 'n Klein aantal normale hoë hellings van 20° tot 90° kom ook voor. In die mynwerkerye kan golwings en koepelvormige strukture plek-plek bespeur word en ook verskuiwings kom voor (sien fig. 3).

DIE BESKRYWING VAN DIE VOORKOMSTE

RUSTENBURG–MARIKANASEKTOR

Hierdie sektor sluit die voorkomste in tussen Rustenburgspoorwegstasie en 27° 30′ oosterlengtegraad.

DIE ONDERSTE GROEP LAE

Die chromietlae kom almal in piroksiniet voor en is horisontaal van 2,000 tot 3,000 treë van die Merenskyrif geleë. Op sommige plekke is ten minste 11 lae aanwesig en hulle wissel in dikte van minder as 1 tot 50 duim (sien fig. 4 en 5). Op die plaas Rietfontein 338 J.Q. word die Hooflaag, wat 6 voet dik is, op 'n diepte van 70 of meer voet ontgin.

DIE MIDDELSTE GROEP LAE

Die horisontale afstand van hierdie groep lae vanaf die Merenskyrif is van 1,700 tot 3,200 treë. Die volledigste opeenvolging van chromietlae in hierdie groep kom op Kroondal 304 J.Q. voor. Omtrent ses lae, wat in dikte wissel van 8 tot 51 duim, word hier aangetref. Van hierdie lae is Laag A die belangrikste maar die erts is van lae gehalte (sien fig. 8). Op Waterval 306 J.Q. is 'n dagsoom van omtrent 20 voet in dikte, maar dit is ook van lae gehalte.

DIE BOONSTE GROEP LAE

Die meeste van die chromietlae in hierdie groep word naby of in anortosiet gevind. Hierdie rots, wat 'n baie handige gidslaag is, vorm 'n dagsoom 50 tot 200 treë wyd en dit is orals in hierdie sektor aanwesig. Verskeie lae is in hierdie groep aanwesig en 'n dikte van 44 duim is aangeteken. Die lae is geneig om lensvormig te wees (sien fig. 9).

RUSTENBURG–BOSHOEKSEKTOR

ONDERSTE GROEP LAE

Die chromietlae in hierdie sektor kom voor tussen die spoorwegstasies Rustenburg en Boshoek.

Net soos in die vorige sektor word die chromietlae hier ook in pirokseniet aangetref. Op Boshoekfontein 268 J.Q. word 'n laag van 12 duim, met 'n helling van 10° tot 15° weswaarts, aangetref. Dit is egter van swak kwaliteit. 'n Laag van dieselfde dikte kom ook op Turffontein 262 J.Q. voor. Op Boekenhoutfontein 260 J.Q. kom die Hooflaag en die Gidslaag voor. Hiervan word die eersgenoemde, met 'n dikte van 6 voet, ontgin. Op Bultfontein 259 J.Q. kom die Hoof- en Gidslaag voor. Een laag van 24 duim word hier ontgin. Verskeie dunner lae word ook gevind.

MIDDELSTE GROEP LAE

Horisontaal is hierdie groep lae van 1,460 tot 3,100 treë vanaf die Merenskyrif. Die belangrikste voorkoms van chromiet in hierdie groep is op Bultfontein J.Q. 259 (sien voublad 5). Die laag het hier 'n dikte van 2½ tot 4 voet, en die vloer bestaan uit anortosiet en die dak uit piroksieniet. Ander lae wat tot hierdie groep behoort is dun en van geen ekonomiese belang nie.

DIE BOONSTE GROEP LAE

Net soos in die vorige sektor, kom die meeste van die chromietlae naby of in die anortositiese band voor. Die afwesigheid van dagsome bemoeilik die opsporing van die verskillende lae. Op Kookfontein is 10 lae sigbaar in 'n spruit. Hulle kom oor 'n horisontale afstand van 170 treë voor, maar is almal dun en dus nie ekonomies ontginbaar nie.

KORRELASIE VAN DIE AFSETTINGS

Wagner ([28], bl. 16) het eers voorgestel dat die chromietafsettings in drie horisonte ingedeel kan word, maar blykbaar het hy drie afsonderlike lae, nie groepe lae nie, bedoel. Later ([31], bl. 17–19) het hy egter sonder twyfel elke horison as 'n groep lae beskou. Die onderverdeling van die „Chromietsubsone in die Kritieke Sone" is deur Kupferbürger ([18]) en ander navorsers gebaseer op afstand van die Merenskyrif af. Ongelukkig is hierdie verdeling nie altyd moontlik nie, soos in tabel 1 aangetoon word. Die huidige korrelasie word gebaseer op—

(*a*) die tipe newegesteentes;

(*b*) diktes van chromietlae;

(*c*) merkersones;

(*d*) merkbare ritmes in die opeenvolging van die lae.

DIE ONDERSTE GROEP LAE

Kupferbürger e.a. ([18], bl. 10) lei af dat chromiteit meestal gepaard gaan met pirokseniet in die onderste groep. Die huidige ondersoek bewys dat die chroomdraende pirokseniet uitsluitlik voorkom in die basale gedeelte van dié onderafdeling van die Bosveldkompleks wat uit pirokseniet, noriet en anortosiet bestaan, en dat die lae in die boonste gedeeltes gepaard gaan met noriet en anortosiet. Al die lae is dus hier verbonde aan die belangrikste chromietdraende pirokseniet.

Die belangrikste lae aan hierdie groep verbonde is die Hooflaag en Gidslaag. Die eersgenoemde is die dikste en wissel van 36 tot 40 duim en op plekke is dit 6 voet dik. Die Gidslaag kom van 8 tot 18 duim bokant die Hooflaag voor en wissel van 12 tot 18 duim in dikte (vergelyk fig. 1 en 4 en voublaaie 1, 2, 4 en 5).

Die Roamerlaag kom 'n paar voet onderkant die Hooflaag voor en bestaan uit 3 tot 6 dun lagies chromiet wat op plekke as 'n merker gebruik word in boordery. Daar word beweer dat die hooflaag in die weste moontlik deurlopend is tot by die Steelpoortrivier in die ooste, 'n afstand van 40 myl. Selfs die Magasyn-, Gids- en Roamerlae noord van Northam toon verwantskappe met lae naby Rustenburg en 'n korrelasie is nie uitgesluit nie, tenspyte daarvan dat hulle 50 myl van mekaar is.

DIE MIDDELSTE GROEP LAE

Twee anortosietlae kom voor bokant die boonste pirokseniet van die onderste groep in albei die genoemde sektors. Hierdie anortosietlae vorm 'n duidelike merker vir die chromitietlae. In fig. 6, 7 en 8 en voublaaie 1 en 4 word die voorkoms van die lae in profiele aangetoon. 'n Korrelasie is moontlik tussen chromitietlae A en B in fig. 7 en laag D in fig. 8.

Die vier lae op Waterkloof 4 kom waarskynlik ooreen met die vier lae aangetoon in fig. 8.

DIE BOONSTE GROEP LAE

Die meeste van die lae in hierdie groep kom voor naby of in 'n anortosietband, wat feitlik deur die hele gebied gevolg kan word. Die aanwesigheid van fyn strepies chromiet in die rots op plekke toon aan dat chromietlae moontlik in die onmiddellike omgewing aanwesig is. Op Kroondal 304 J.Q. en Brakspruit 299 J.Q. kom die chromietlae net onder die anortosietband voor. Die korrelasie van die lae in hierdie groep is eenvoudig.

DIE EIENSKAPPE VAN DIE ERTS

CHEMIESE EIENSKAPPE

'n Aantal chemiese analises is gemaak van die erts wat in die verskillende groepe voorkom, en dit is duidelik dat die chromiet 'n komplekse mengsel van chromiet en pikotiet verteenwoordig, en dat die verhouding tussen die twee minerale baie wissel. Die analises word in tabelle 3, 4 en 5 aangegee. Metale van die platinumgroep kom plek-plek voor in die chromiet en wissel van nul tot minder as 2 dwt. per kleinton. Die analises bewys verder 'n aansienlike wisseling in die graad van die erts van een plek na die ander, selfs in dieselfde laag. Die erts kan oor die algemeen bestempel word as van 'n lae tot medium graad.

FISIESE EIENSKAPPE

MINERALOGIE EN PETROGRAFIE VAN DIE CHROMITEIT

Swart, blink kristalle van chromiet vorm die vernaamste bestanddeel van die chromitiet en die belangrikste silikate is bowlingiet en ortopirokseen. Basiese plagioklaas, alkaliveldspaat, silika, magnesiet, glimmer en uvaroviet is almal bykomstige minerale.

INDUSTRIËLE ERTSSOORTE

Vir industriële doeleindes word die erts as krummelrig en hard klonterig beskrywe.

(*a*) *Krummelrige erts*

Hierdie soort verpoeier maklik in die mynbouproses en as dit aan die lug blootgestel word. Die meeste van die erts is van hierdie soort. Hierdie eienskap word toegeskrywe aan die feit dat silikate slegs in 'n klein persentasie aanwesig is, sodat die afkoeling stadig plaasvind en krummelrigheid as gevolg het.

(*b*) *Hard klonterige erts*

Hierdie soort verkrummel nie wanneer dit gehanteer of aan die lug blootgestel word nie, en daar is 'n groter aanvraag omdat dit makliker vervoer kan word met 'n minimum van verlies. Daar is twee soorte: die eerste is 'n natuurlik massiewe erts wat plek-plek in die krummelrige tipe voorkom en die tweede is 'n saamgeperste erts wat ontstaan het as gevolg van beweging in die laag, en wryfvlakke bevat.

Al die myne, behalwe dié op Kroondal, pas 'n sekere mate van konsentrasie toe alvorens die erts bemark word. Op hierdie manier word die persentasie chroomoksied van 2 tot 2·9 verhoog.

PRODUKSIE EN BEMARKING

Na die ontdekking van die Hooflaag op *Bultfontein* 359 *J.Q.* het mynbouaktiwiteite hier in Junie 1955 begin, toe drie skuins skagte gegrawe is.

Op *Boekenhoutfontein* 260 *J.Q.* het oppervlakuitgrawings en ook mynbou plaasgevind voor 1929. In 1931 het die „ Western Chrome Corporation " meer aktief begin myn en groter produksie het gevolg. Hierna volg 'n lang periode sonder aktiwiteit, totdat daar in 1953 weer 'n begin gemaak is. Die huidige daaglikse opbrengs is omtrent 40 kleinton, met 'n koste van 20 tot 25 sjielings per ton.

„ Marble Lime and Associated Industries " het in 1947 op *Kroondal* 304 *J.Q.* 'n begin gemaak met die myn van die chromiet. Omtrent 250 kleinton erts word daagliks geproduseer en die grootste gedeelte hiervan word plaaslik verbruik.

Op *Rietfontein* 338 *J.Q.* is mynbou weer begin gedurende 1954 deur „ Pondoland Minerals ", nadat daar 5 jaar lank geen produksie was nie. In 1956 is alle chroombelange op hierdie plaas deur Farbenfabriken, Bayer (Duitsland) oorgeneem.

Prospekteerwerk word tans (1956) uitgevoer op *Kookfontein* 265 *J.Q.* deur „ Cullinan Refractories, Ltd.". 'n Gedeelte van die erts word op die oppervlak gewin en verder word die pilaarafboumetode aangewend.

Die totale produksie van chromiet vanaf 1924 tot 1955 op die vier genoemde plase kom te staan op 397,742 kleinton, sodat dié delfstof vandag een van die belangrikste onedele delfstowwe van die Unie is.

Die erts word gegradeer volgens die gebruik waarvoor dit bestem is: vir metallurgiese doeleindes, vuurvaste materiaal en skeikundige doeleindes. Die wêreldverbruik is soos volg: ferrochroom, 45 persent; vuurvaste stowwe, 40 persent; en chemiese stowwe, 15 persent. Vir die produksie van ferrochroom word die harde klonterige erts benut, met nie minder nie as 48 persent Cr_2O_3 en Cr en Fe in die verhouding van 3:1. Vuurvaste ertse het gewoonlik 'n hoë inhoud Cr_2O_3 en A1, maar 'n lae yster- en silika-inhoud. Die minderwaardige ertse word gewoonlik vir skeikundige doeleindes gebruik, en hiervoor is die spesifikasies minder streng.

Die tipiese analises vir chemiese, metallurgiese en vuurvaste ertse word in table 8 aangegee.

Die Transvaalse erts is minder vuurvas as dié van Rhodesië en kan vinniger gesmelt word in 'n elektriese oond. 'n Legering wat steeds meer byval vind in die produksie van vleklose staal direk van die erts is ontwikkel en word gebruik deur „ African Metals Corp., Ltd. ". Deur middel van hierdie metode kan die Unie van Suid-Afrika van die goedkoopste vleklose staal in die wêreld produseer.

Voordat die reserwes van erts bereken kan word, is kennis van die deurlopendheid van die verskillende chromietlae in die gebied nodig. Aangesien dagsome van die chromietlae en bygaande rotse soms baie skaars is, is dit nodig dat baie meer intensiewe prospekteerdery aangepak word om gegewens te bekom.

As aanvaar word dat die Hooflaag van die onderste groep aanwesig is waar die chroomdraende piroksieniet voorkom, dan kan 'n redelike noukeurige skatting van die reserwesyfer vir hierdie laag gemaak word. As aangeneem word dat die diepte van die Hooflaag langs die helling 500 voet is oor 'n strekkingslengte van 25 myl, kan die reserwesyfer gestel word op 19,550,000 ton.

GEVOLGTREKKINGS

1. Dit is moontlik om dié gedeelte van die Bosveldstollingskompleks wat voorheen Kritieke Sone genoem is in definitiewe en deurlopende horisonte en merkers in te deel.

2. Die metode van indeling in die gebied onder bespreking mag elders ook van nut wees.

3. Die moonlike deurlopendheid van 'n ekonomiese merker, die „ Hoofhorison ", in die onderste groep is tentatief vasgestel, wat mag van nut wees in toekomstige geologiese opnames. Stelselmatige prospekteerdery word sterk aanbeveel.

4. Aan die basis van die middelste groep lae is 'n laag van meer as 2 voet aanwesig; dié feit regverdig verdere opsporing.

5. Die chromitiet is oor die algemeen van lae gehalte. Die onderste groep lae bevat die beste kwaliteit erts.

ADDENDUM

List of farms mentioned in this bulletin, giving the former and present farm-numbers:—

	Former number	Present number
Beerfontein	432	263 J.Q.
Boekenhoutfontein	336	260 J.Q.
Boschfontein	489	268 J.Q.
Boschkoppie	685	104 J.Q.
Boshoek	268	103 J.Q.
Brakspruit	293	299 J.Q.
Bultfontein	354	259 J.Q.
Kafferskraal	352	133 J.Q.
Kafferskraal	915	342 J.Q.
Klipfontein	538	300 J.Q.
Kookfontein	337	265 J.Q.
Kroondal	177	304 J.Q.
Palmietfontein	567	208 J.P.
Rietfontein	290	338 J.Q.
Rooikoppies	171	297 J.Q.
Schildpadnest	233	*
Spruitfontein	349	341 J.Q.
Swartkop	355	*
Turffontein	297	262 J.Q.
Uitvalgrond	334	105 J.Q.
Vaalkop	677	275 J.Q.
Waterkloof	4	305 J.Q.
Waterval	544	306 J.Q.

* No new number allocated at time of publication.

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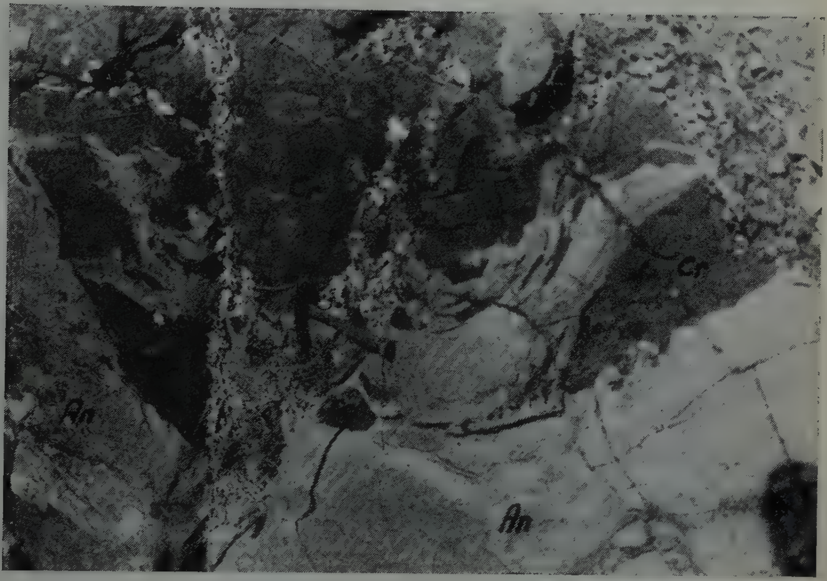
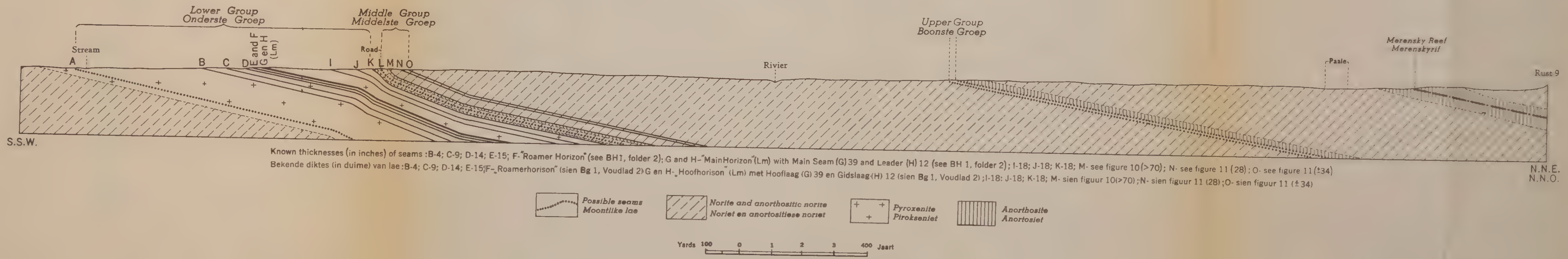


Distorted chromite seam (Cr.) in anorthosite (An.) on Turffontein 262 J.Q.
Vervormde chromietlaag (Cr.) in anortosiet (An.) op Turffontein 262 J.Q.

Folder 1
Voublad 1

SECTION ACROSS THE CHROMITITE SEAMS ON KROONDAL 304 JQ
PROFIEL OOR DIE CHROMITIETLAE OP KROONDAL 304 JQ

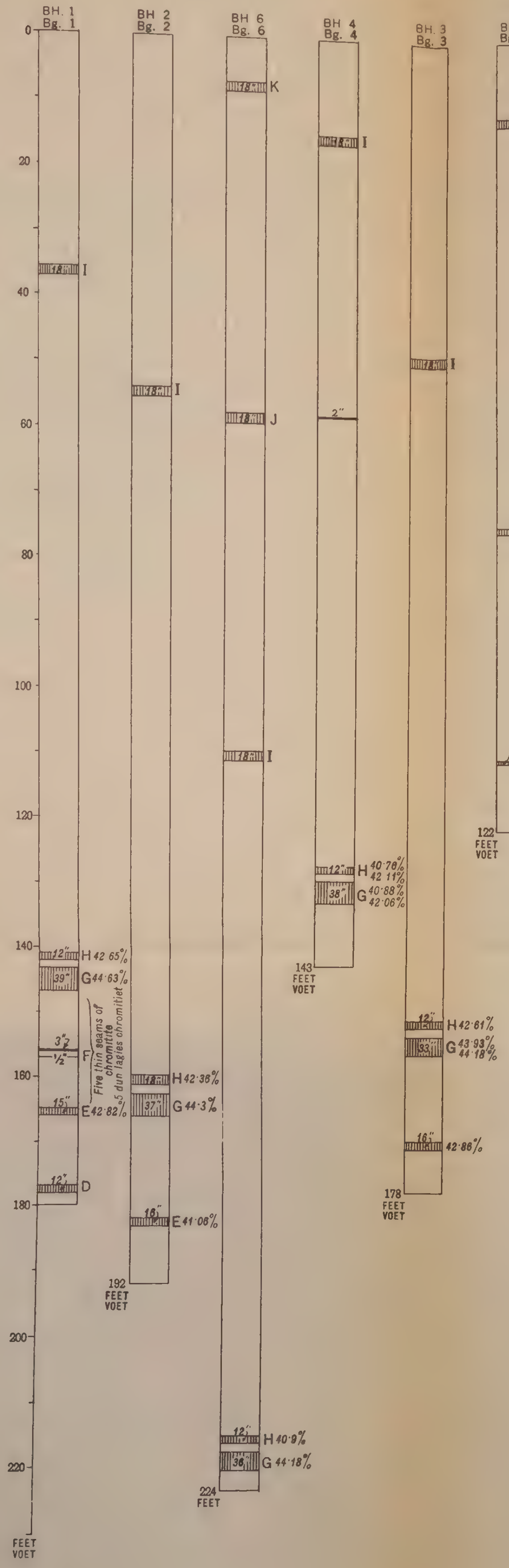


Known thicknesses (in inches) of seams : B-4; C-9; D-14; E-15; F-"Roamer Horizon" (see BH 1, folder 2); G and H-"Main Horizon" (Lm) with Main Seam (G) 39 and Leader (H) 12 (see BH 1, folder 2); I-18; J-18; K-18; M- see figure 10 (>70); N- see figure 11 (28); O- see figure 11 (±34)

Bekende diktes (in duime) van lae : B-4; C-9; D-14; E-15; F-„Roamerhorison" (sien Bg 1, Voudlad 2) G en H-„Hoofhorison" (Lm) met Hooflaag (G) 39 en Gidslaag (H) 12 (sien Bg 1, Voudlad 2); I-18: J-18; K-18; M- sien figuur 10 (>70); N- sien figuur 11 (28); O- sien figuur 11 (± 34)

Folder 2.
Voublad 2.

SECTIONS OF BORE-HOLES IN LOWER GROUP OF SEAMS ON KROONDAL 304 JQ
PROFIELE VAN BOORGATE IN ÒNDERSTE GROEP LAE OP KROONDAL 304 JQ



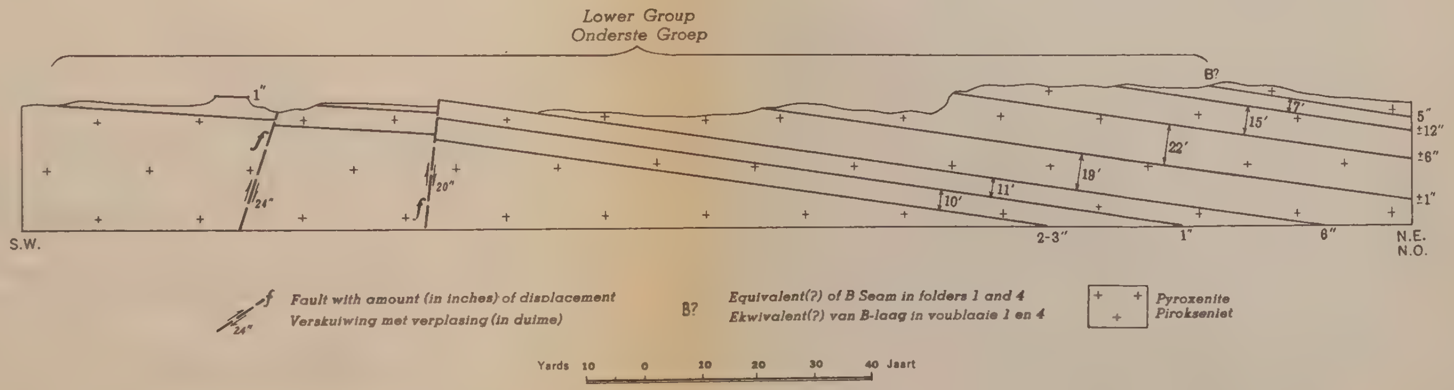
H Leader Seam
Gidslaag
G Main Seam
Hooflaag
"Main Horizon"
„Hoofhorison"
F "Roamer Horizon"
„Roamerhorison"

Content of chromic oxide indicated after each seam of "Main Horizon" as supplied by Marble, Lime and Associated Industries Ltd.

Inhoud van chroomoksied word na elke laag van die „Hoofhorison" aangedui. Inligting bekom van Marble, Lime and Associated Industries Ltd.

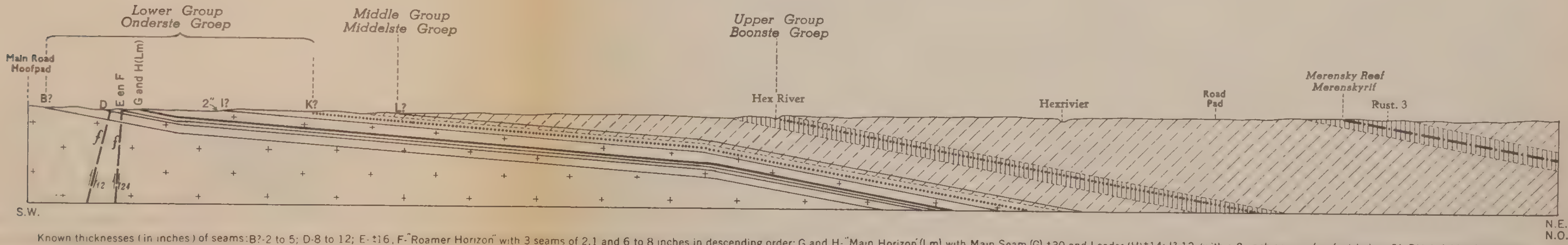
Folder 3
Voublad 3

SECTION ACROSS THE CHROMITITE SEAMS AS EXPOSED IN A QUARRY ON WATERKLOOF 305 JQ
PROFIEL OOR DIE CHROMITIETLAE SOOS BLOOTGELÊ IN ´N STEENGROEF OP WATERKLOOF 305 JQ


Lower Group
Onderste Groep
B?
1"
f
24"
f
20"
10'
11'
19'
22'
15'
7'
5"
±12"
±6"
±1"
S.W.
2-3"
1"
6"
N.E.
N.O.
f
24"
Fault with amount (in inches) of displacement
Verskuiwing met verplasing (in duime)
B?
Equivalent(?) of B Seam in folders 1 and 4
Ekwivalent(?) van B-laag in voublaaie 1 en 4
Pyroxenite
Piroksениet
Yards 10 0 10 20 30 40 Jaart

Folder 4.
Voublad 4.

SECTION ACROSS THE CHROMITITE SEAMS ON WATERVAL 306 JQ
PROFIEL OOR DIE CHROMITIETLAE OP WATERVAL 306 JQ



Known thicknesses (in inches) of seams: B?-2 to 5; D-8 to 12; E-±16, F-"Roamer Horizon" with 3 seams of 2,1 and 6 to 8 inches in descending order; G and H-"Main Horizon"(Lm) with Main Seam (G) ±30 and Leader (H) ±14; I?-12 (with a 2-inch seam a few feet below. Cf. BH.4, folder 2); L?-±24

Bekende diktes (in duime) van lae. B?- 2 tot 5; D- 8 tot 12; E ±16; F-„Roamerhorison" met 3 lae van 2,1 en 6 tot 8 duim in dikte van bo na onder; G en H-„Hoofhorison" (Lm) met Hooflaag (G) ±30 en Gidslaag (H) ±14; I(?)-12 (met 'n 2 duim laag 'n paar voet ondertoe. Vgl. Bg. 4, voublad 2); L(?)-±24

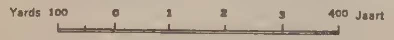
Possible seam Alphabetical designation of the seams refers to equivalents in folder 1
Moontlike laag Die alfabetiese benaming verwys na ekwivalente lae aangetoon in voublad 1

Fault with amount (in inches) of displacement
Verskuiwing met verplasing (in duime)

▨ *Norite and anorthositic norite*
Noriet en anortositiese noriet

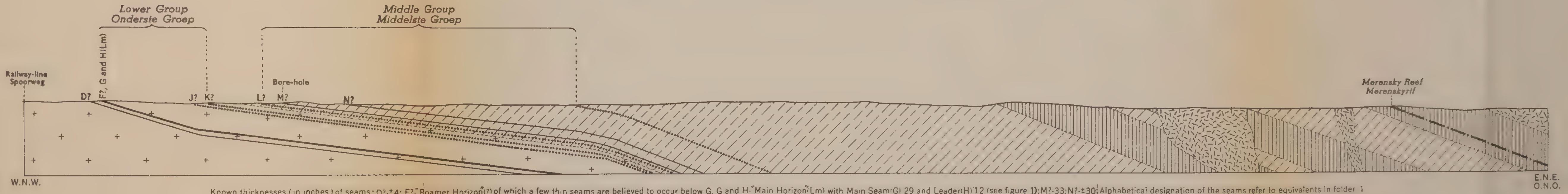
Pyroxenite
Piroksenieit

Anorthosite
Anortosiet



Folder 5.
Voublad 5.

SECTION ACROSS THE CHROMITITE SEAMS ON BULTFONTEIN 259 JQ
PROFIEL OOR DIE CHROMITIETLAE OP BULTFONTEIN 259 JQ

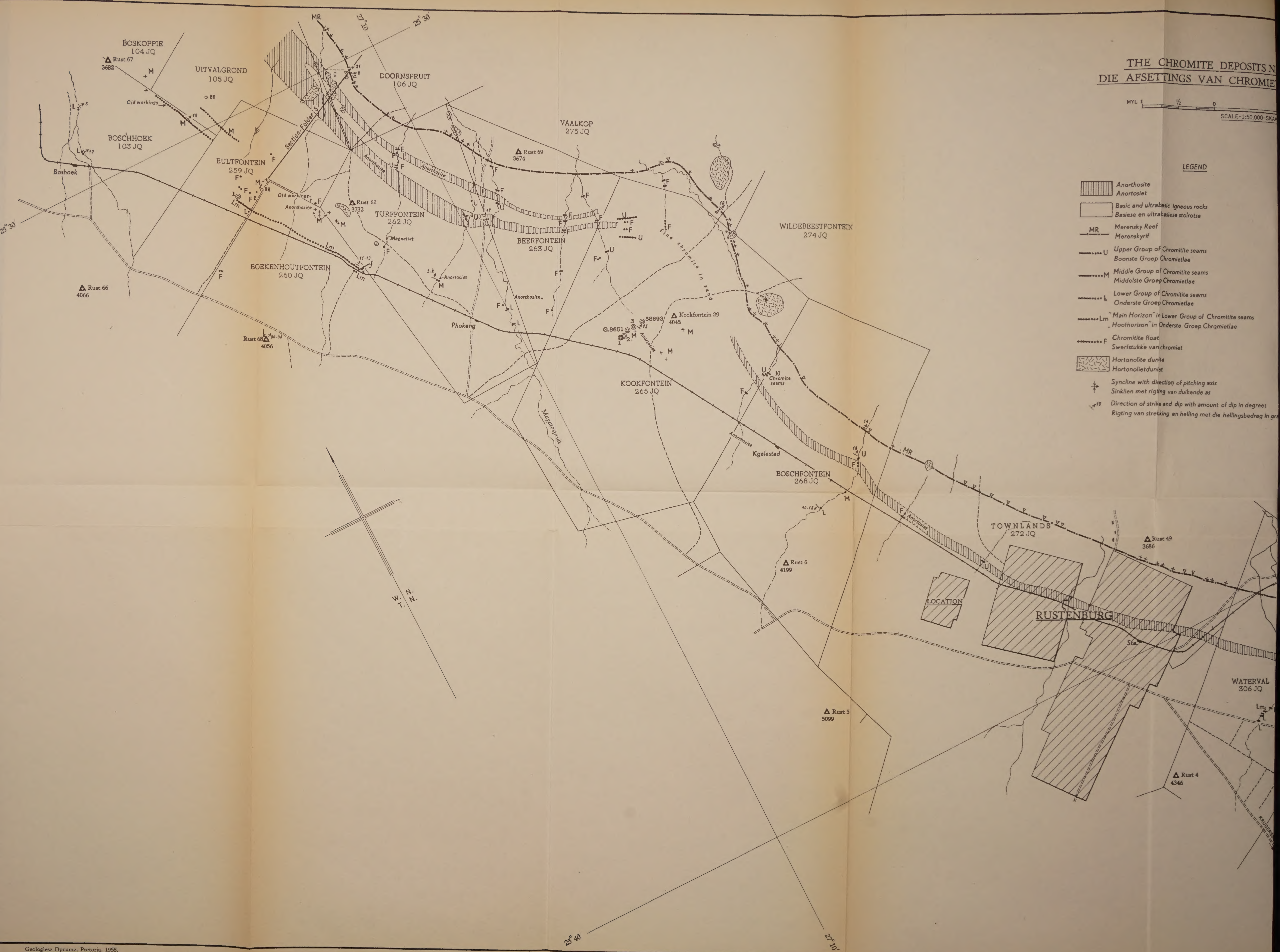


Known thicknesses (in inches) of seams: D?-±4; F?-"Roamer Horizon"(?) of which a few thin seams are believed to occur below G. G and H-"Main Horizon"(Lm) with Main Seam (G) 29 and Leader (H) 12 (see figure 1); M?-33; N?-±30; Alphabetical designation of the seams refer to equivalents in folder 1

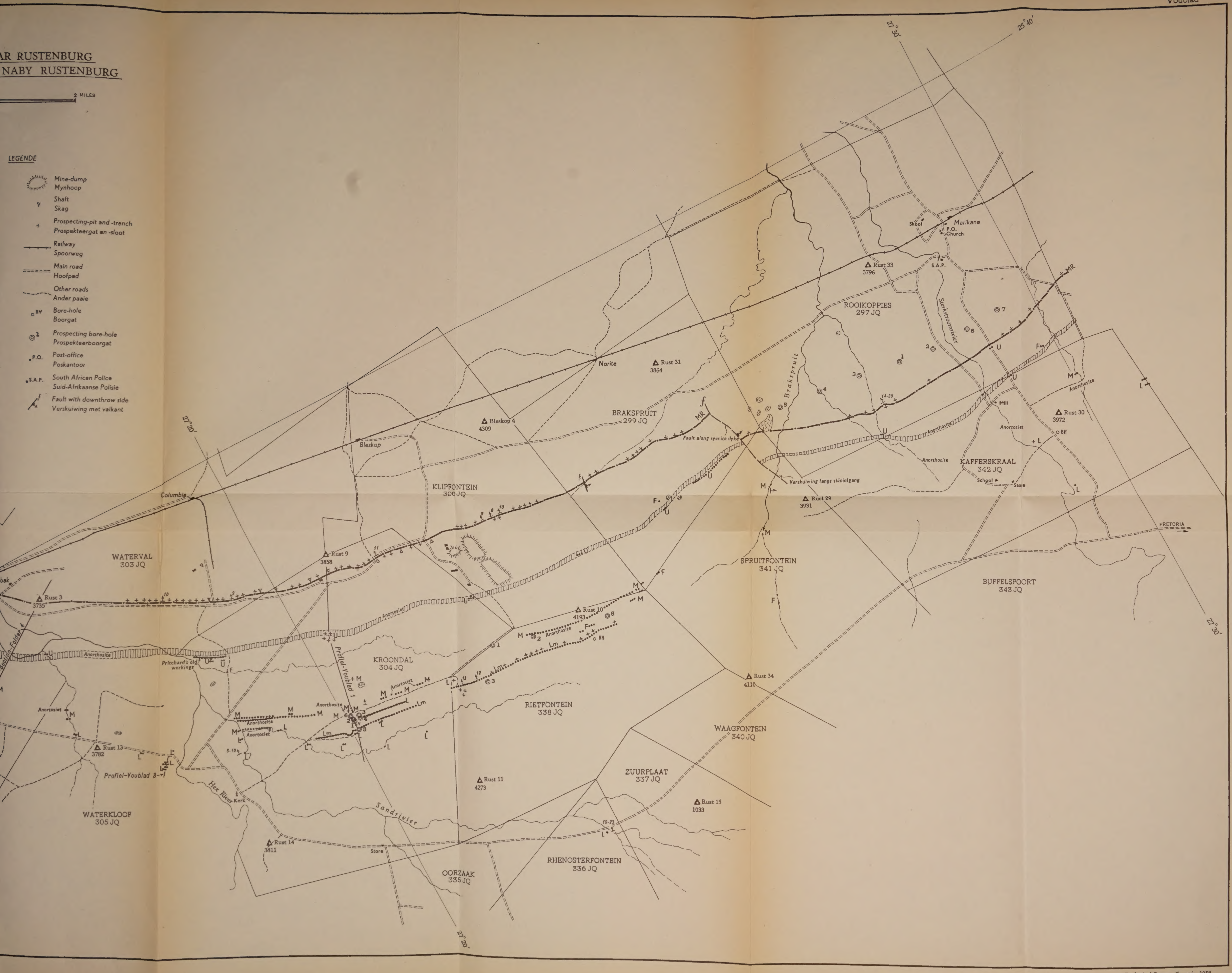
Bekende diktes (in duime) van lae; D?-±4; F?-„Roamerhorison"(?) waarin 'n paar dun lae vermoedelik onderkant G voorkom. G en H-„Hoofhorison"(Lm) met Hooflaag (G) 29 en Gidslaag (H) 12 (sien figuur 1); M?-33; N?-±30; Alfabetiese benaming van die lae verwys na ekwiwalente in voublad 1

+ + +	*Pyroxenite* *Pirokseniet*
▨	*Norite and anorthositic norite* *Noriet en anortositiese noriet*
⁘	*Hortonolite dunite* *Hortonolietduniet*
▥	*Anorthosite* *Anortosiet*
……	*Possible seam* *Moontlike laag*

THE CHROMITE DEPOSITS N
DIE AFSETTINGS VAN CHROMIE



Geologiese Opname, Pretoria. 1958.



Geological Survey, Pretoria, 1958